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TAKING THE BOTTOM PIECE OF THE LAST BOX OUT TO THE PIER HEAD

BREAKWATERS ON THE WEST COAST OF JUTLAND.—[See Page 216]

The Preparation of Gas for Balloons*

What Chemistry Has Done for Ballooning

By A. Sander

Technical chemistry has contributed a very important share to the successful development of aerial navigation within the past few years; for a number of products of chemical industry function as important auxiliaries in the construction and operation, both of dirigible balloons and of aeroplanes. It is only necessary to call to mind the several special steels and the light aluminium magnesium alloys, which are of the highest importance as materials of construction for aeronautical purposes; or the India rubber used for impregnating the light and yet highly resistant and tough gas-proof balloon fabric; there is also the very important item of gasoline and oil, on the proper chemical purification of which the safe operation of the motor depends in a large measure; lastly there is the important problem of the production of the balloon gas, which places before the technical chemist a number of difficult problems for solution. Just as in a flying machine the motor is the vital point, so in ballooning the preparation of the buoyant gas is of fundamental importance.

Before turning to the consideration of the technical production of the balloon gas, it will be well first of all to briefly call to mind its purpose and the requirements which it is called upon to fulfill. The purpose of balloon gas is, of course, to lift a car, which together with its passengers, ballast, and apparatus, has a considerable weight. The dimensions of the balloon and car must be so chosen that the weight of the entire system is less than that of the air displaced thereby. Hence the first demand laid upon balloon gas is that it shall be very light as compared with air. This, however, is not by any means the only condition which has to be satisfied. The ideal balloon gas, which unfortunately is as yet but an ideal, should in addition to low density possess the following properties: It must not attack the balloon envelope and should be incombustible, in other words it should be chemically inert. Furthermore, it should be as little as possible affected by changes in temperature, it should be readily liquefiable, non-poisonous, and last but not least, it must be cheap. While a large number of gases might be cited which fulfill more or less satisfactorily the first condition, that of low density, when we strike from such a list all those gases which fail to satisfy one or other of the remaining conditions, we are left with practically only three substances as having hitherto been used for a balloon filling, and they are heated air, illuminating gas, and hydrogen. We will briefly consider each of these in turn:

I. *Heated Air.*—The art of aerial navigation may be said to date from the year 1783, in which the Montgolfier Brothers made a public ascent in their home in Brittany, by the aid of a paper balloon covered with linen and inflated with hot air. It is on record that these same inventors had in the first instance experimented with steam as a filling for the balloon, the idea being suggested to their mind by the sight of the clouds drifting in the sky. In point of fact steam would make a very fair gas for ballooning were it not for the impossibility of preventing its condensation. The Montgolfier hot-air balloon had a number of obvious limitations. The fact that fire had to be carried on board placed the occupants in considerable jeopardy owing to the risk of the balloon itself being set in flames. Furthermore, the extreme height to which it could ascend was only about 8,000 feet, for in order to rise higher than this it would be necessary to heat the air above 100 deg. C., which could not be done without injuring the balloon cover.

II. *Illuminating Gas.*—Of much greater importance than hot air for ballooning purposes is the use of illuminating gas. Its introduction into the art is usually ascribed to an Englishman, Greene, in 1818; it has, however, been demonstrated from old documents by Dutch chemists that illuminating gas was used as early as 1783 in their country, that is to say, in the very same year in which the brothers Montgolfier made their first ascent.

At the present day gas works are the principal centers from which most balloon ascents take place, and the quantity of gas consumed for this purpose is rapidly increasing. A very brief resumé of the preparation of illuminating gas may here suffice, inasmuch as its mode of manufacture is more or less a matter of common knowledge owing to its extended use in everyday life. As is well known, illuminating gas is prepared by the "dry distillation" of coal. This process is usually carried on in fire clay retorts arranged in batteries of six to twelve in one furnace. The gas issuing from the retorts is passed through an elaborate and extended series of apparatus in which it is cooled and freed from certain impurities. The purified gas is collected in so-called gasometers, whence it is forced into the mains for general distribution. Illuminating gas is colorless, but readily recognized by its odor. It is not a chemical individual, but a mixture of gases, its principal constituent, amounting to about fifty per cent, being hydrogen. The composition of the gas is somewhat variable, and in consequence its density also fluctuates between about 0.36 and 0.52 (expressed in the scale which gives to air the density 1). This corresponds to a lifting power of 0.052 to 0.39 pound per cubic foot. As regards density the requirements of balloonists and of the general consumer of illuminating gas are at variance, for as a balloon filling a light gas rich in hydrogen is the desideratum, while for illuminating purposes a gas rich in the heavier illuminants is more advantageous. Nevertheless there are few gas works in Germany whose product has density greater than 0.45. Heavier gas occurs only where exclusively silesian coal is distilled, or where much water gas is added.

In the course of the distillation of coal the composition of the gas issuing from the retorts varies considerably, and especially toward the end of the distillation a very light gas rich in hydrogen is obtained. It has therefore been suggested to collect the last portions, which are of comparatively low illuminating value, separately, and to utilize them for ballooning purposes. This mode of procedure would, however, introduce considerable complication into the manufacture of coal gas, and has therefore found no application in practice. On the other hand a method which of recent years has been applied with much success, consists in converting the purified gas into a lighter product by heating it at a high temperature. This process is not altogether a new invention; in the year 1894 Bunte and others had observed that by this treatment ordinary illuminating gas can be made to yield a product containing about 80 per cent hydrogen and having a density of about 0.2. The process was, however, not put into practice until very recently, when Dr. von Oechelhäuser gave publicity to the fact that a gas company in Dessau had succeeded in producing a special balloon gas by simply heating illuminating gas to 1,200 deg. C. The apparatus used is very simple. The gas is passed through highly heated retorts charged with small coke. At the temperature indicated the hydro-carbons are split up into their constituents, as for example:

$$CH_4 = C + 2H_2$$

This change is accompanied by an increase in volume of 20 per cent, while the carbon is deposited upon the retort walls in the form of soot or graphite. The gas produced is passed through a small purifying plant and into a gas holder. The additional cost of converting the ordinary illuminating gas into balloon gas is just about the same as the cost of distributing the ordinary gas to consumers, so that the price of balloon gas at the works should be about the same as the price of illuminating gas at the point of consumption. The specific gravity of the balloon gas fluctuates between 0.225 and 0.3, with an average of about 0.27 and a lifting power of about 59 pounds per cubic foot. This corresponds to $26 to $34 per ton of lifting power (German conditions). The gas contains about 80 per cent hydrogen and only 5 per cent of methane; it is free from benzine and other hydrocarbon which would attack the balloon envelope; it has a very much weaker odor than ordinary coal gas, and is much less sensitive to temperature changes

While this process of making balloon gas represents a very considerable advance for the purposes of ordinary balloons, it is hardly likely that it will ever have any value for dirigible balloons. For on account of the great weight of such crafts it is necessary to employ the highest buoyancy available, so that the only gas which enters into consideration is hydrogen.

III. *Hydrogen.*—The lightest of all known gases is hydrogen, whose density compared with air is 0.07. It has the further advantage for ballooning purpose of being comparatively non-sensitive toward temperature changes. It is very hard to liquefy, hardly soluble in water, and diffuses with great ease even through the smallest openings. This last is the reason why the attempts of the brothers Montgolfier to fill paper balloon envelopes with hydrogen were entirely unsuccessful. The physicist, Charles of Paris, was the first to succeed in sending up a balloon filled with hydrogen. He prepared the gas by the action of dilute acid upon iron. The balloon envelope was made of silk taffeta. Although its volume was less than 1,400 cubic feet, it took three days and three nights to fill, and required no less than 1,100 pounds of iron filings and 550 pounds of acid. The method which Charles used for generating the gas was extremely wasteful of material. Coutelle's attempt to prepare hydrogen on a large scale by passing steam over red hot iron did not prove well adapted for large scale working. A great step forward was made by Renard and Giffard, who used the same reaction as Charles, but modified the process by feeding continually fresh quantities of acid to the iron while drawing off the iron sulphate liquor. In this way a much more complete utilization of the iron was secured. Nevertheless this process also represented an extremely costly method of preparing hydrogen. It was only toward the end of the nineties that a new source of hydrogen became available, and almost completely drove out the old process. This new source is the electrolytic hydrogen produced by the Fabrak Griesheim-Elektron, who produced large quantities of hydrogen as a by-product in their electrolytic process of manufacturing caustic alkali. This industry has at the present day reached such a scale that the firm named above produces in its three works daily no less than 700,000 cubic feet of hydrogen. Although of late years the consumption of this gas has increased very greatly, as a matter of fact only a small portion of the gas is at present collected and compressed into steel cylinders at 120 to 150 atmospheres, while the bulk of it is discharged into the atmosphere. The placing upon the market of hydrogen from this source has done much to further the interests and development of aerial navigation in Germany. The electrolytic hydrogen possesses some very remarkable advantages owing to its purity and more especially its freedom from arsenic. This has led to the establishment of plants built especially for the electrolytic production of hydrogen on its own account, that is to say quite apart from the manufacture of alkali. For this purpose the electrolyte is simply water rendered conducting by the addition of a small percentage of acid, or preferably alkali. The advantage of alkali is that its use permits the employment of iron vessels and diminishes the wear and tear of the electrodes.

While electrolytic hydrogen possess the advantages which have been referred to, it unfortunately presents at the same time rather severe drawbacks. Thus the number of costly steel cylinders required for a large production is quite excessive. Furthermore, there is added to the cost of production, which it is true is moderate, the cost of compressing the gas, and, there is obtained as a by-product with every two volumes of hydrogen one volume of oxygen, an outlet for which must be found. Lastly, the item of freight is very considerable, especially in view of the fact that the return of the empty cylinders represents practically the same expenditure as the first shipment of the charged cylinders. In view of the immense gas consumption of the modern air ship, such as for instance the Zeppelin type of fifteen thousand cubic meters (528,000 cubic feet) capacity, it has become imperative to look for a process of manufacture of hydrogen which would render it possible to produce large quantities of gas at moderate cost, and which would obviate the use of compressed gas and of steel cylinders. A process of this kind has been installed at Friedrichshafen by the Carbonium Company, based upon the splitting up of acetylene and other hydrocarbons into their components. The gases are decomposed by electric sparks into carbon and hydrogen in cylinders provided with stirring gear. The carbon which is deposited in the form of soot is the principal product, and it is claimed that the material so obtained is superior to that from other sources for the production of printers' ink, paint, and other uses. No data are available at the present time as to the practical operation of this process, owing to the fact that a part of the works was destroyed by an explosion last July. Indications, however, seem to be that the process will represent a very economical source of hydrogen.

Another process, which has been worked out by the International Hydrogen Company, of Frankfurt-on-the-Main, is based upon the reaction between steam and red hot iron discovered by Lavoisier. As has been mentioned above, an attempt to turn this to technical account had been made years ago by Coutelle, without success. The difficulty was to reduce the oxide of iron formed in the process back into iron, so as to restore

* Adapted from *Zeitschrift für angewandte Chemie.*

the raw material and render it available for further use. It has been discovered that pyrites cinders are very well adapted for the process. They are very porous and for this reason readily reducible to metallic iron by passing generator gas over them. On leading steam over the reduced iron so obtained, a very pure 98 per cent hydrogen is readily prepared.

Another very promising process has been introduced by Siemens and Halske, and starts from calcium carbide as raw material. As is well known to every layman at the present day, this substance when treated with water under ordinary conditions yields acetylene. The inventors have discovered that the reaction proceeds along an entirely different course if the calcium carbide is treated with steam at red-heat. The formation of acetylene and other hydrocarbons is almost completely avoided and the reaction proceeds essentially according to the following equation:

$$CaC_2 + 5H_2O = CaO + 2CO_2 + 5H_2.$$

From the mixtures so obtained the carbon dioxide can be readily extracted by passing the gases over some of the lime, produced in a previous run. The apparatus required is extremely simple and the raw material is cheap, so that this process ought to find wide application.

We now come to a group of processes all starting from the same raw material, namely, water gas. This gas, as is well known, consists of a mixture of about 50 per cent hydrogen and 50 per cent carbon monoxide (C O). In practice the gas is contaminated with a certain proportion of carbon dioxide and nitrogen. The density of water gas is 0.52 to 0.54, so that it might be directly utilized for balloon filling; owing to its highly poisonous character, however, this would be very undesirable and dangerous.

The first efforts to use water gas as a source of pure hydrogen dates many years back. At first the endeavor was to simply carry out the water gas process in such manner that only a small proportion of carbon monoxide was formed. Gillard found that if an excess of steam was used the carbon monoxide was oxidized to carbon dioxide, which latter can readily be eliminated from the mixture. The reaction is simply

$$C + 2H_2O = CO_2 + 2H_2.$$

It is, however, very difficult to carry this out in practice on a large scale, and to-day the efforts in this direction have been practically abandoned. It is now the general practice to start out from the finished product, water gas, and either to eliminate the carbon monoxide by absorbing agents, or to introduce in its place an equal volume of hydrogen. As absorbing agent cuprous chloride has been used, but the product obtained by its means contains only 80 per cent hydrogen. A considerably better result is obtained according to Frank and Caro, by passing water gas through retorts containing moderately heated calcium carbide. This reagent absorbs not only the carbon monoxide but also the carbon dioxide and the nitrogen. There is thus obtained a very pure gas, and in addition to this two valuable by-products, namely, graphite and calcium cyanamide. A still simpler method of eliminating the carbon monoxide is by liquefaction. This process also has been introduced into practice by Frank and Caro in collaboration with Linde. The liquid carbon monoxide obtained as a by-product is utilized in a gas motor which furnishes the power for compressing the water gas. Still another process has been worked up by the Chemische Fabrik Griesheim-Elektron, in which the carbon monoxide is replaced by an equal volume of hydrogen. The principle on which this process is based is as follows: When moist water gas is passed over lime heated to 500 deg. C. calcium carbonate is formed and hydrogen is liberated.

$$CO + H_2O + CaO = CaCO_3 + H_2.$$

In order that the product may contain as high a percentage of hydrogen as possible, it is essential that the water gas be nearly free from nitrogen, a condition which can be fulfilled by the use of specially designed generators. Considering that this process makes use of only water gas and lime for its raw materials, it ought to prove extremely cheap.

Very similar to the preparation of producer gas is the oil gas process. It consists in blowing oil instead of steam into a generator charged with red hot coke. In this way it is possible to obtain directly a gas containing as much as 90 to 96 per cent of hydrogen. A special advantage of this process is that the installation can readily be designed in transportable form, being mounted upon two railroad trucks. The importance of this for aerial navigation in military operations is very obvious, although it may be necessary to carry the portability even farther than is possible with this arrangement. As a matter of fact, in the Boer War the English Army carried hydrogen in steel cylinders, using camels as beasts of burden. Each camel transported two bottles of 140 cubic feet capacity. For the service of the English balloons having a capacity of 1,400 cubic feet a train of fifty camels was therefore required. In the Russo-Japanese War the method employed by the Russian Army consisted in the generation of hydrogen from aluminium and caustic soda. This reaction proceeds very rapidly, rendering special cooling precautions necessary. The method is of course very expensive. Another process which is specially adapted for military purposes is based on the reaction

$$H_2O + Si + 2NaOH = Na_2SiO_3 + 2H$$

The special advantage of this is that only two kilograms of silicon are required for the production of one cubic meter of hydrogen. This process was used by Spain in the Morocco campaign. Lastly may be mentioned the production of hydrogen from calcium hydride, a gray substance prepared by passing hydrogen over molten calcium. This substance reacts with water, liberating hydrogen according to the equation

$$CaH_2 + H_2O = Ca\ (OH)_2 + 2H_2.$$

The production of one cubic meter of hydrogen requires the use of only one kilogram of calcium hydride. The process has hitherto been used only for filling small pilot balloons, but it would seem to be well calculated to fulfil the requirements of military practice.

This concludes a review of the most important processes which have been proposed, and carried out with some measure of success, for the production of balloon gas. It is impossible at the present time to judge which of the numerous methods proposed will ultimately prove the best. But this can be said, that the problem as a whole is well on the way towards solution, and that the keen competition which is at work among the several processes now recognized as practically feasible, will bring results in the near future, so that we shall soon have at our command one or more thoroughly practical processes, satisfying the various conditions imposed by the conditions of consumption.

The Effect of Radium on the Higher Animals

Prof. London's Researches

In 1903 Danysz observed that tubes containing radium, introduced under the skin in the region of the brain or spinal cord, produced symptoms of paralysis in three hours and tetanic convulsions in six hours. The effect was greatest in the youngest animals. Similar results were obtained by a different method by Prof. London, the celebrated Russian physiologist, from advance sheets of whose forthcoming work on "Radium in Biology and Medicine," as reprinted in *Die Umschau*, the following account is derived. Prof. London exposed mice to the radiation of 30 milligrams of radium placed above their cage, within an inch or less of the animals. On the third day of the exposure the mice became dull and sleepy and their ears became red. On the fourth day these symptoms were more serious; the hind legs became paralyzed, and the animals died on the fourth or fifth day.

In 1904 London exposed three rabbits to the action of radium in a similar manner. During two weeks no morbid symptoms appeared. On the sixteenth day the ears reddened and red spots appeared on other parts of the body. These spots developed into ulcers which gradually healed. Six or eight weeks after the beginning of the experiment the ears were almost entirely bald and the hair began to fall from the back. The bald places then became inflamed and ulcerated. After sixteen months the ears were greatly thickened and deformed and covered with crusts, and the entire back was destitute of hair. In the eighth month motor disturbances appeared. The animals gradually lost control of their hind legs, until finally they moved forward by means of their fore legs alone, dragging themselves on their bellies with their hind legs trailing helplessly.

The eyes were frequently examined and in all cases were found more or less affected. The greatest changes were produced in the retina. As death approached the eyes were generally quite closed and covered with a thick secretion. The retina was not equally affected in all cases, probably because the radium rays fell upon it only when the eye was directed toward the tube.

For several months no effect on the sexual functions was observed and the female gave birth to three litters, in July, September and November. Afterwards the sexual impulse progressively weakened and finally vanished.

Despite the fact that the injurious influence of the radiation soon appeared, the rabbits steadily increased in weight at first, but they afterward lost weight very rapidly.

London also investigated the influence of radium emanation on frogs and white mice. Two frogs were placed in two 2-quart glass bottles containing a little water. One of these bottles was connected for two days with a vessel in which emanation was being evolved, and was then disconnected and corked. After three days it was uncorked and allowed to remain open 48 hours, and was then again connected with the radium vessel for 48 hours, after which it was again disconnected and corked. When the experiment was arranged in this manner, the frog died three or four days after the second dose of emanation, while the control frog in the other bottle remained in perfect health.

The same result can be obtained by permanently connecting one of the bottles with the source of emanation. In this method the successive phases of the effect can be followed more satisfactorily. The morbid symptoms, which begin to appear on the sixth or seventh day, include sluggishness of movement, sleepiness, slimy appearance of the skin and difficulty in respiration, which causes death on the thirteenth to fifteenth day. The attitude of the frog and the appearance of the water are characteristic. In the control vessel, the frog stands in a normal manner on all fours and the water remains clear, but in the vessel exposed to emanation the frog's head and chest are extended forward and the water is turbid.

The frog exposed to the emanation exhibits a radioactivity which can be detected on the first day. Very interesting experiments can be made in the dark with frogs killed in this way. Thus it can be shown that the frog emits Alpha, Beta and Gamma rays, and photographs itself on a sensitive plate covered with black paper. The imprint is most distinct when the exposure is continued three hours. The most strongly radio-active portion is the skin. If part of the skin is removed and the experiment is repeated, the outline of the section removed appears distinctly in the photograph. The blood was found very dark and the skin abnormally soft. The microscope showed extensive changes in the skin and spinal cord.

In another experiment three or four suckling mice were placed in a bottle into which radium emanation had been admitted during 48 hours. The bottle was then corked and the mice were left exposed to the action of the emanation for four hours, after which the bottle was uncorked, the mice remaining in it two hours longer. The same number of mice of the same litter were placed in another bottle, not containing emanation, for comparison. During the entire experiment and the two following days the mice showed no abnormal symptoms. On the third day the mice which had been exposed to the emanations lay on their sides, breathed with difficulty, and died with symptoms of dyspnoea. Death came more quickly in proportion to the length of exposure to emanation. The cause of death is probably to be sought in a disturbance of respiration.

Electricity from Falling Drops of Water

Some time ago, A Schmauss showed that drops of water falling through ionized air take up a negative charge. Seeliger experimenting with ordinary water in Munich, found that in ordinary air no negative charge was gained, and when ionized by Röntgen rays only a quite feeble negative charge was assumed. To explain this, Seeliger supposes a charge effect due to Volta p.d. The author in the present paper seeks to show that Seeliger's explanation is not tenable, and, further, goes on to explain the cause of the want of agreement between his own results and those of Seeliger. It appears that the taking up on an ionic charge from the air depends on the kind of water used, and while Schmauss's result is obtained with distilled water, Munich tap water behaves in the way described by Seeliger. Experiments with NaCl solution show that this assumes a positive charge when it falls in drops through ionized air, and, in general, Seeliger's results may be explained by the following experimental facts: (1) Distilled water which exhibits a positive charge as Lenard effect, takes up a negative charge in the drop experiments; (2) NaCl solutions (and perhaps also Munich tap water) which shows a negative charge as Lenard-effect, takes a positive charge. The opposite behavior of distilled water and NaCl solution shows that a charge action caused through Volta p.d. of the metallic parts of the apparatus is not the explanation of the effects, but that there must rather be assumed specific forces acting between the liquid drops and the surrounding positive and negative ions. The drops may draw to themselves those ions whose charge is opposite to their own on account of the charge arising from the Lenard double layer.—*Annalen der Physik.*

The Air-brake as Related to Progress in Locomotion—I*

The History of a Great Invention

By Walter V. Turner, Chief Engineer, Westinghouse Air Brake Co., Pittsburg, Pa.

GENERAL AND HISTORICAL.

Every moving body is capable, by virtue of its motion, of doing an amount of work before its motion can be diminished or stopped, which is directly proportional to the weight of the body and to the square of the speed at which it is moving. In the case of a vehicle, means must be provided which will permit this work to be done harmlessly and in a proper and predetermined manner. Otherwise the element of danger involved increases so rapidly with the weight and speed of the vehicle that locomotion, except in its most primitive stages, is prohibitive. The development of locomotion and consequently of transportation is, therefore, dependent in no small degree upon a like or even superior progress in the art of controlling vehicles in motion.

The laws according to which this art progresses can be determined only by following the successive developments which have been made in train control apparatus. This will be treated briefly in what follows, dealing primarily with the principles upon which such apparatus must operate, the methods, both theoretical and practical, by which these principles have been and are being applied to the problem in hand, and the fundamental conditions of service which fix the requirements that must be satisfied by a reliable and practical device of this character.

Primitive Vehicle Brakes.—Knowing that the ancients traveled extensively, and that the great empires of history moved large armies over the then known world, accompanied by trains of baggage wagons and war machines, it is natural to suppose that the necessity for retarding those vehicles must have been plainly manifested. But as a matter of fact, the first suggestion of this necessity by the use of a practical mechanism designed for the purpose does not appear to have been more than 250 to 300 years ago. The primitive carts and wagons which were used in agricultural work, and in connection with the transportation of baggage and supplies for armies, were of such construction that the natural resistance to rotation of their wheels was quite sufficient to bring them to a stop upon ordinary roads; and in cases of steep grades it was always easy to chain a log or stone (Fig. 1) to the back of the wagon, so that by dragging it over the ground the speed of the vehicle was checked.

* Presented at the meeting of the Mechanical and Engineering Section.

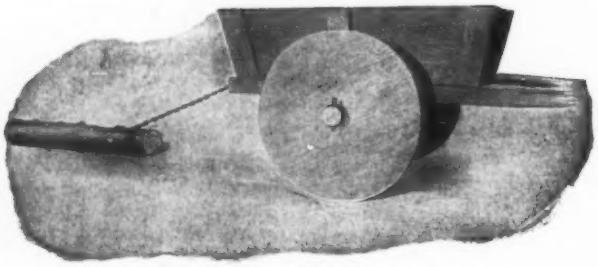


Fig. 1.—THE DRAG

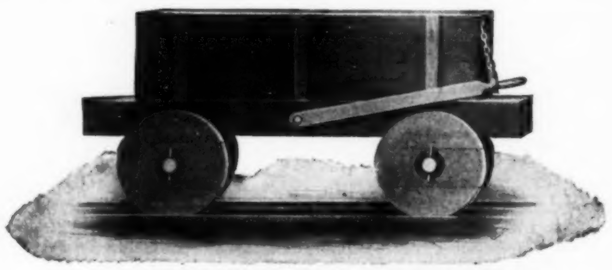


Fig. 2.—PRIMITIVE RAILWAY WAGON BRAKE

Indeed, to find the time when the question of braking first came into prominence, it is necessary to go no further back than the period when highways became sufficiently well made and maintained as to admit of a heavy vehicle being drawn over them at comparatively high speed.

A remarkable adherence to one basic combination of elemental parts, of the same general character and function, is to be observed in even the earliest types of brake apparatus. This extends from the simplest primitive forms through the entire progress of the art until they are found to-day, associated, it is true, with great specialization and complexity of detail, but still having essentially the same fundamental components.

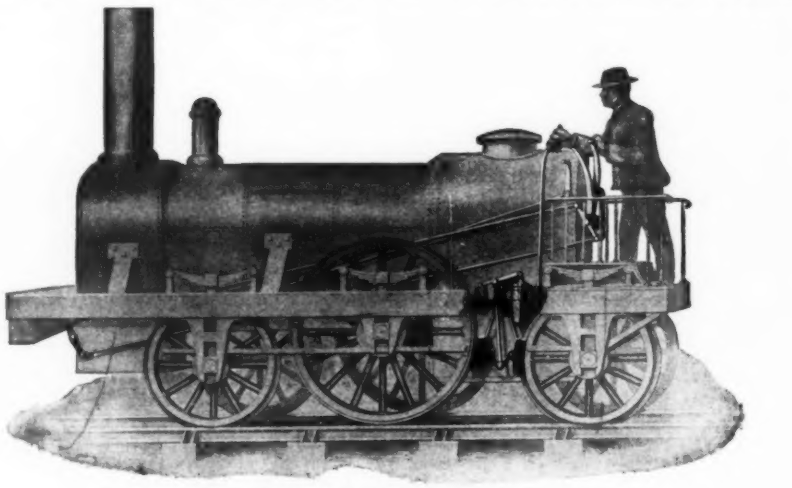


Fig. 4.—STEVENSON'S STEAM LOCOMOTIVE BRAKE

This is natural, because, as the moving vehicle must be controlled by self-contained apparatus, it was first necessary to devise means whereby a source of energy or pressure, located on the vehicle, might be made to generate retarding force, opposed to the motion of the vehicle.

It is easy to see that the revolving wheels and axles offer the convenient and practicable opportunity required, and, consequently, it is not surprising to find that practically all brake devices, no matter how widely diversified in details, have one feature in common. This consists of a block or brake shoe, as it is called, so located that it may be pressed against the wheel tread with more or less force as may be necessary. This develops a frictional force or pull between the relatively stationary shoe and the revolving wheel which, so long as it does not exceed the "adhesion" of the wheel to the rail or roadway on which it rolls, tends to retard and finally stop the motion of the wheel and thereby of the vehicle itself.

It can be proved by experiment that the "adhesion" of a wheel to a rail while rolling (static or, more properly, rolling friction) is greater than the frictional force at this point when the wheel is sliding (kinetic friction). Therefore, the maximum retardation on the vehicle as a whole is obtained when the brake shoe pressure is such as to produce a frictional force at the shoe nearly but not quite sufficient to cause the wheel to slide. This explains why wheel sliding must be avoided for theoretical as well as practical reasons.

Early Railway Brakes.—One of the earliest and simplest means of retarding the wheels of a vehicle in this way was forced by a change in existing conditions, just as the many subsequent changes in methods of locomotion have been responsible for the perfection of the brake as we know it to-day. About the year 1630 an enterprising mine owner at Newcastle-on-Tyne, finding the roads between his mine and the river so bad as to seriously interfere with the hauling of coal, conceived the idea of laying wooden rails in the road and running his cars thereon. The tractive effort of these cars was thereby so much increased that the necessity of some contrivance to check their speed was at once apparent and brought out simple forms of brakes. One of these forms consisted of a metal-tipped beam which was fastened to the frame of the car in such a way as to scrape along in the ground at the side of the track. Another form was a simple lever pivoted to the side, near the center of the car, and ordinarily held up by a chain, which, when desired for use could be liber-

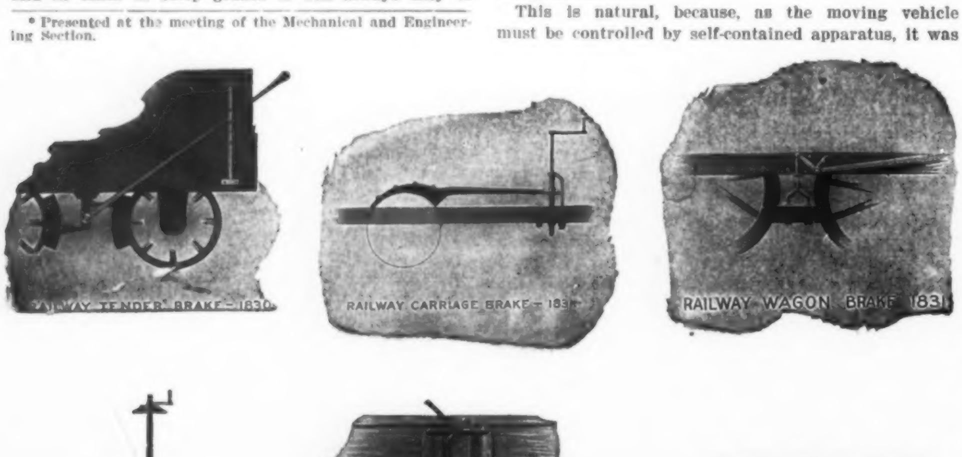


Fig. 3.—SIMPLE AND EARLY TYPES OF HAND BRAKES

ated and pressed by hand or foot against the top of the wheel, as shown in Fig. 2.

Many other simple devices of like nature were adopted by such rail or tram-roads as then existed, which require mention only to point out that all made use of a block or shoe forced against the tread of the wheel either directly, or through the medium of some simple combination of rods and levers, whereby the strength of the man applying the brake might be augmented or multiplied (Fig. 3).

The Steam Brake.—As the speeds on these roads were generally quite low and the cars small enough to be drawn by draught animals, such devices served all practical purposes until the inauguration of a new order of things, by the advent of the steam locomotive. With the speeds and weights of cars which then had to be reckoned with it soon became evident that something better than a manually operated brake was needed. In 1833 Stevenson patented his steam brake (Fig. 4), in which steam pressure, acting on a movable piston, was made to take the place of the hand-operated mechanism by which the force was applied through a system of rods, multiplying levers (and cams in this case) to the brake shoe. In this first form of power brake we have all the elements of a complete power brake, viz.:

1. Source of power—steam.
2. Means whereby this power may be made to act upon the rods and levers of the brake rigging proper —a "brake" cylinder with movable piston and rod.
3. Connecting rods and multiplying levers to transmit and increase the pressure exerted on the brake piston—called the foundation brake gear.
4. Means for transmitting the force exerted through the foundation brake gear to the wheels as retarding force or "pull"—this being the function of the brake shoes as already explained.

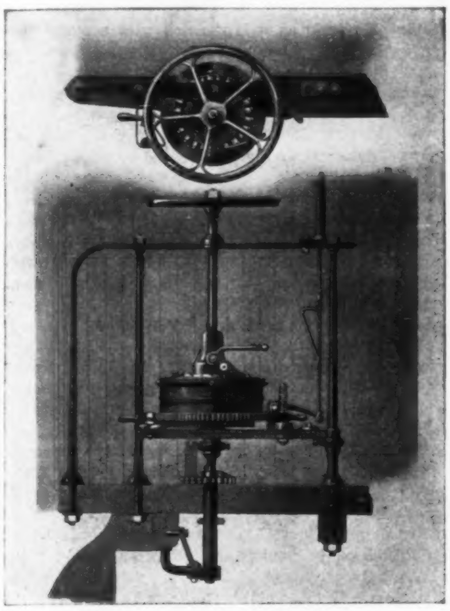


Fig. 5.—CREAMER BRAKE, 1853

In the case of the cars, the hand-operated brake, with various forms of foundation brake gear, met all practical requirements for some time, though a general realization of the necessity for some form of power brakes is attested by the fact that during the first seventy years of the nineteenth century about 650 patents were granted in England for various kinds of brakes for railroad service.

PNEUMATIC BRAKE.

The first pneumatic brake was a vacuum brake patented by James Nasmyth and Charles May in 1844. In 1848 Samuel C. Lister patented an air brake having an axle-driven pump and suitable reservoir to be placed on the "Guard's Carriage," and suitable cylinder, pipe, and connections on the various cars to constitute a straight air equipment much the same as that which followed many years after, except that it was designed to be operated by the guard and not by the engineer.

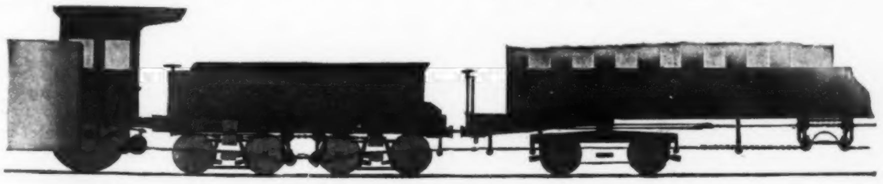


Fig. 6.—LOUGHRIDGE CHAIN BRAKE, 1855

Continuous Train Brake.—Of course, the earlier types of hand brakes underwent considerable improvement, but while the majority of passenger, as well as freight cars, were braked by hand, as more and heavier cars came to be handled in the same train, the necessity for a "continuous" brake or one capable of being put in action on the various cars comprising the train, at the will of the engineer himself, became more and more evident. Some of the various systems originating in this country were extensively tried and seemed to meet the conditions for which they were designed with various degrees of success. The "Creamer" brake (Fig. 5), which was brought into use in 1853, consisted of a large spiral spring attached to the brake staff, at the end of the car, and which was wound up by the brakeman immediately after leaving a station. Attached to the mechanism was a cord which ran through the train to the engineer's cab, and the brake was so designed that when the engineer pulled the cord, the coil springs on each vehicle were released and these at once wound up chains leading to the foundation brake gear, thereby bringing the brake shoes against the wheels.

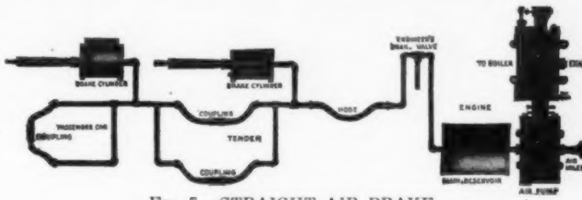


Fig. 7.—STRAIGHT AIR BRAKE

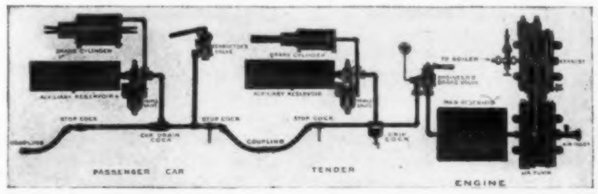


Fig. 8.—THE "WESTINGHOUSE" PLAIN AUTOMATIC AIR BRAKE, 1872

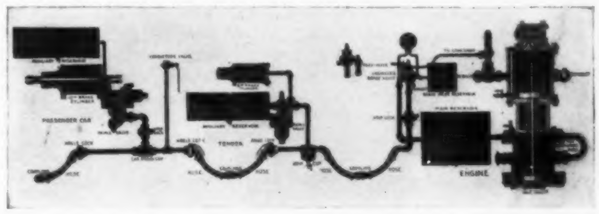
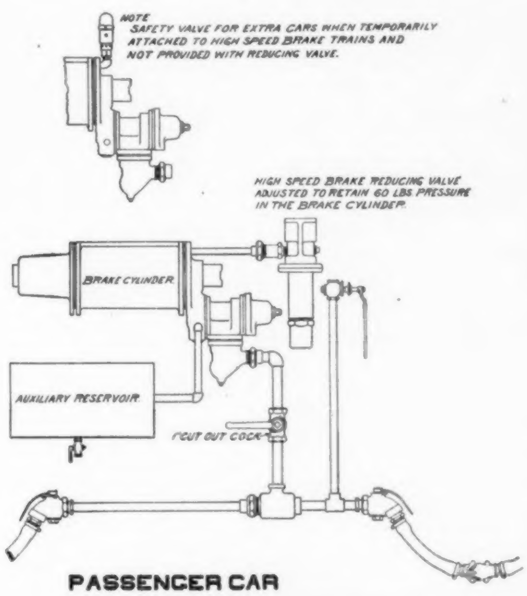


Fig. 9.—THE "WESTINGHOUSE" SYSTEM QUICK-ACTION AUTOMATIC BRAKE, 1887

The "Loughridge Chain Brake" (Fig. 6), which came into use in 1855, consisted of a system of rods and chains continuously connected throughout the train, as follows: On each vehicle were two pairs of small pulleys, each pair sliding toward the other upon an iron framework, but held apart by a spring; to each pair was connected a top rod leading to the foundation brake gear. Upon the engine was placed a drum connected by a worm and gear to a small friction wheel; when a lever in the engineer's cab was pulled this friction wheel was brought into contact with the periphery of one of the driving wheels, thereby causing the drum to wind up the chain and shorten its length throughtout the train; in so doing the pulleys upon each vehicle were brought closer together, thereby applying the brakes.



PASSENGER CAR

Fig. 10.—HIGH-SPEED PASSENGER BRAKE

In addition to the above, various forms of continuous brakes, other than air brakes, were tried to a greater or less extent from time to time. Among these may be mentioned the Smith Vacuum Brake, the Westinghouse Vacuum Brake, the Eames Vacuum Brake, the Fay Mechanical Brake, the Clark & Webb Chain Brake, the Barker Hydraulic Brake, the American Buffer Brake, the Widdifield & Button Friction Buffer Brake, the Rote Buffer Brake, the Carpenter Electric Air Brake, and the Card Electric Brake. From the length of this list it will be seen that to give an adequate description of these various systems would be to occupy with matter of purely historical or curious interest, valuable space and the time of the reader which promise already to be overtaxed by the demands of modern practice and recent development.

While these types of brakes were the result of much ingenuity and skill, and attained to a degree of success sufficient to prove the necessity for, and advantage of a reliable and efficient continuous brake,

none of them satisfied enough of the fundamental requirements of a practicable, continuous brake to result in their universal acceptance as a standard in this country.

The Air Brake—Straight Air Type.—The first steps of the complete solution of the problem were taken, and a new line of development opened up, by the genius of Mr. George Westinghouse, who, in 1869, took out his first patents for the Westinghouse Non-Automatic Air Brake, since generally designated as the "Straight Air Brake."

The source of power adopted for this system was the expansive force or pressure of compressed air, obtained from a steam actuated air pump placed upon the side of the engine, and a reservoir in which the compressed air could be stored. A pipe line from the reservoir was carried throughout the length of the train, connections between vehicles being made by means of flexible hose and couplings. Each vehicle was provided with a cast-iron cylinder, the piston rod of which was connected to the brake rigging in such a way that when the air was admitted to the cylinder the piston was forced out and the brakes thereby applied. A three-way cock or valve located in the engineer's cab by means of which compressed air could be admitted to the train pipe and thus to the cylinders on each car to apply the brakes; or the air already in the cylinders and train brake pipe could be discharged to the atmosphere, thus releasing the brakes.

An early form of the Straight Air Brake is shown in Fig. 7. The air pump is one of the first forms to come into general use, the so-called "trigger" or "jigger" valve motion and octagonal piston rod being features of particular interest.

This type of apparatus has many good qualities and a very large degree of flexibility, that is, the increase or decrease of the pressure or braking power, so-called, was under the control of the operator to a very marked degree, but had shortcomings which made it unsuitable for use on trains of any considerable length on account of the time required to apply and release the brake and the unequal braking effort throughout the train. More important still, the factor of safety was low; as no warning was given in the event of the hose coming uncoupled, and a parted train meant no brakes. Thus it is seen that it lacked the first essentials of an efficient brake, which is, that it must be its own "tell-tale." That is, if an accident occurs to the system, it must result in a brake application instead of a loss of the brake.

PLAIN AUTOMATIC AIR BRAKE.

In the natural process and development of railroads, the requirements became more exacting and it was evident that the straight air brake was not only unsuitable for the reasons just mentioned, but that it lacked essential features. It became more than ever important that the brake must apply automatically in case of the train parting. This was so fundamentally necessary that even if the flexibility of the straight air brake had not already been lost to a large extent by the lengthening of the trains, it would have had to be abandoned because of the infinitely greater safety inherent in a brake of the automatic type. Therefore, the straight air brake, having served its purpose as an advance agent of something better, gave way to the automatic brake, which afterwards came to be called the "plain automatic brake," to distinguish it from a later type that locally reduced the brake pipe pressure, thus producing what is called "quick action."

The first form of this brake, probably the greatest advance ever made in the art, was invented and introduced by Mr George Westinghouse in 1872 (Fig. 8).

The automatic feature resulted from the obtaining of an indirect application of the brakes through the medium of a valve device called a triple valve, and an auxiliary storage reservoir, which were added to the brake cylinder on each car. All of the triple valves were connected together by a continuous pipe, called the brake pipe, with flexible connections between the cars; this pipe being charged with air whenever the brakes were in operative condition. By this means, the auxiliary reservoir was charged with compressed air for braking purposes on the vehicle to which it was attached; therefore, it was no longer necessary to transmit the air from the locomotive to the vehicle when an application of the brakes was desired. The triple valve is the essential mechanical element in such a system, possessing the three functions of charging the auxiliary reservoir and of applying and releasing the brakes in accordance with variations in the air pressure carried in the brake pipe; the medium for producing such operations as desired, being, for all general operations, a manually operated brake valve on the locomotive.

By means of this valve the engineer could apply the brakes either to a part of their capacity, by steps or graduations, or fully, by a continuous decrease of the brake pipe pressure, but he had no control of the release of the brakes (as with the straight air). The automatic brake releasing locally on each car, while the release of the straight air brake was controlled on the engine. Therefore, one of the elements of flexibility possessed by the straight air brake was lost, but, as has been said, this feature had already been very much reduced in value by the lengthening of the train.

Thus, through the instrumentality of the triple valve, the air brake became automatic, which term applies to that *application* of the brakes which occurs through any material depletion from any cause of brake-pipe pressure, either at the will of the engineer, by hose parting, burst hose, leakage, or at the instance of the train crew, so that this system very materially increased the factor of safety and permitted the use of air brake on longer passenger trains, and on the already existing freight trains, in a way that was not possible with the straight air brake equipment.

Quick Action and Automatic Air Brake.—This plain automatic brake was a great improvement in many respects over the straight air brake, but chiefly from an emergency or safety standpoint, for much of the flexibility (that is, the ability of the operator to increase or decrease the cylinder pressure at will and for any desired number of times in rapid succession) for ordinary service brake operations had to be sacrificed. This brake served the purpose fairly well while trains were short, and speeds, weight and frequency low, but as these factors changed, *its* limitations became more and more apparent, particularly with reference to emergency operation. The application was too slow with long trains, *and for* reasons differing only in degree from those which had affected the straight air brake. Thus when a quick application was attempted, the shocks were great, nor was the stop as short as required. The reason for this slowness of operation was because the air in the brake pipe could not be quickly and uniformly reduced throughout its whole length; this, because of increased volume, frictional resistance, and the necessity of its traveling to the one outlet, which was through the brake valve at one end of the train. This limitation was overcome by the invention (in 1887) of the "quick action" triple valve and the equipment with which it was used came to be known therefore as the Quick Action Automatic Brake (Fig. 9). The "quick action" triple valve was identical with the plain triple valve as far as service operations were concerned, but differed from it in emergency in that it automatically vented air from the brake pipe locally on each car. The rapid brake pipe reduction thus resulting is transmitted to the next triple valve and from it serially in the same manner to all the valves in the train, thereby reducing the time of full application to about one sixth of what is inherent with plain triple valves on a fifty-car train, and shocks were therefore correspondingly lessened and stops shortened. The reason for this is that the brake pipe reduction with the plain triple valve took place at only one point in the train instead of fifty as with the quick action valve.

The feature of serial venting of the brake pipe was so important that a second feature of this brake system, which the first mentioned made possible, was, and is to-day, overlooked by many, and perhaps is often not rated at its true value. This feature was the then possible attainment of a different and higher braking power for emergency than for service applications. Up to this time the cylinder pressure, or retarding force, attainable had been the same for both service and emergency application, but now, since the brake pipe pressure vented could be, and, as a matter of fact, was vented into the brake cylinder with one form of the device, the pressure therein was materially increased whenever quick action took place.

From this it will be seen that to the automatic and graduating features of the brake two others were added, namely, serial quick action and difference or increase in braking power between service and emergency applications. All four of these are now generally recognized (though often not appreciated as they should be) as being fundamentally essential in a brake worthy the name. Moreover, these four features have had and still have great possibilities of extension and development. Attention should be called again to the wonderful adaptability of the original combination of brake cylinder, triple valve, and auxiliary reservoir to the ever-increasing need of more powerful, and what naturally follows, a more flexible brake. It is truly remarkable that through all subsequent improvements not one of the original functions of the triple valve has been discarded, but that they have been extended and expanded and many new functions added.

So far, the apparatus employed was the same for both passenger and freight cars, but the still greater frequency of trains, heavier vehicles, and higher speeds made it necessary to provide means whereby a still greater stopping power for passenger service might be available when needed, particularly for emergency applications. This was possible only by increasing the air pressure, since any other method would have made the brake too severe for low speeds; in other words, the percentage of braking power per pound of cylinder pressure was already as great as practical operation would permit.

THE HIGH-SPEED BRAKE.

It was thought, however, that to increase the brake pipe pressure sufficiently to give the desired braking power would result in unpleasant or dangerous shocks, slid and flattened wheels, and other damage from the high brake cylinder pressure obtainable; therefore, this was not done until the valve known as the "high-speed reducing valve" was perfected in 1894. The principles utilized by this type of apparatus had been thoroughly demonstrated by the classic Westinghouse-Galton tests in England in 1878. These tests showed that, while the adhesion between the wheel and the rail—which causes the wheels to persist in their rotation—is practically uniform at different speeds, the friction between the brake shoe and the wheel—which acts as a resistance to the rotation of the wheel, and thereby stops the train—is considerably less when the wheels are revolving rapidly than when they revolve slowly. It was thus demonstrated that a greater pressure not only could be safely applied to the wheels by the brake shoes, at high speeds, but also that such considerably greater brake shoe pressure *must* be applied to the wheels at high speeds, in order to then resist the motion of the train as effectively as it is resisted with a more moderate brake shoe pressure at low speeds. This was accomplished by the use of a higher brake pipe air pressure with the standard quick action apparatus, with only the addition of a high speed reducing valve attached directly to the brake cyclinders. This device was designed to limit the brake cylinder pressure obtainable during a service application of the brakes to what was considered safe and necessary, but when an emergency application of the brakes was made, to permit the brake cylinder pressure to rise to a considerably higher value than the maximum permitted in a service application, and then to cause a gradual reduction of brake cylinder pressure, quite slow at first, but becoming more rapid, so as to proportion, as far as possible, with such a device working on a fixed range, the blowdown of brake cylinder pressure to the reduction in speed as the stopping point is approached. Superior stopping capacity was obtained as already stated, by increasing the brake pipe air pressure from the generally adopted 70 pounds, as used with a quick action brake equipment, to 110 pounds, which in emergency applications and with the sizes to brake cylinder then in use would give about 85 pounds cylinder pressure instead of about 60 pounds, or, in other words, raise the nominal percentage of braking power from 90 to 125 per cent of the weight of the vehicle.

With this improved equipment when an emergency application was made, full cylinder pressure (85 pounds) was quickly obtained, but was automatically reduced to 60 pounds and held at this point by means of the automatic reducing valve. Thus, if the stop was long enough, the initial nominal percentage of braking power was 125 per cent, while the final was 90 per cent, but the actual retardation of the train kept fairly constant due to the difference in the retarding power of the shoes at high and low speeds already mentioned. Though the co-efficient of brake shoe friction was known to be less at high speeds than at low speeds, it was predicted by many that much wheel sliding would result from raising the nominal power above 100 per cent of the light weight of the car, but, on the contrary, wheel sliding was lessened and naturally so when the situation is analyzed.

In service applications, the opening from the reducing valve was larger than in emergency application so that if such a reduction or brake pipe pressure was made as would cause the brake cylinder pressure to rise above 60 pounds, the reducing valve would open and vent the air, which otherwise would cause an undesirably high brake cylinder pressure, to the atmosphere.

This combination, with the quick-action triple valve, is known as the high speed brake, and is illustrated in Fig. 10.

(To be continued.)

Grain Standardization and Wheat

THE study of grain standardization has been progressing satisfactorily. Three hundred samples of various varieties, classes, and grades of wheat were experimented with in connection with the improvement of the handling and marketing of this crop. The important study of seed testing for the purpose of improving the quality of the different seeds and for ascertaining the particular seeds for different climates is being rapidly developed. The Department of Agriculture has been directing special effort to extend the area of possible cultivation of hard winter wheat by the introduction of varieties harder than those now grown. The Kharkov variety has proved to be the best.

Correspondence

The Bergen-Christiania Railway Contrasted with Two American Railroads

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:

The description of the grades of the Bergen-Christiania Railway, given in the SCIENTIFIC AMERICAN of February 11th last, gives a basis for a profile, which I have constructed and present herewith. For purpose of comparison, I have prepared outline profiles of two American railroads on the same scale and covering nearly the same distance.

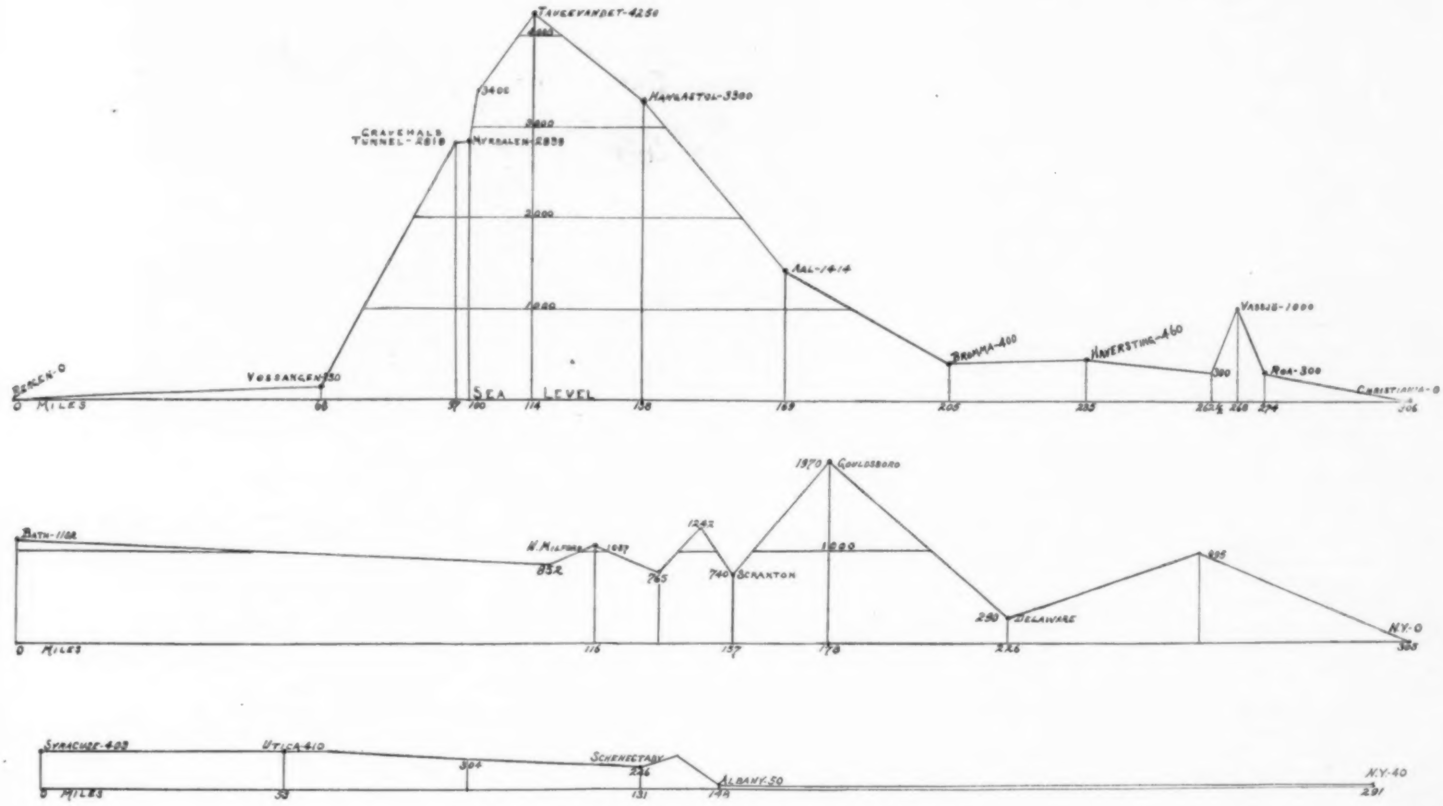
The Bergen-Christiania Railway was recently opened across the Scandinavian peninsula, and the profile shows how it climbs the mountains in order to save forty out of fifty-four hours of travel. Owing to the necessary difference between the horizontal and vertical scales, the grades are, of course, greatly exaggerated.

Fig. 2 shows the Delaware, Lackawanna and Western Railroad for nearly three-fourths of its distance between New York and Buffalo. At its highest point, in crossing the Pocono Mountains in Pennsylvania, it is nearer the clouds than any of the four other trunk lines between the two cities, yet considerably less than half as high as the Scandinavian Railway. The steady climb westward to Bath at 1,102 feet is continued, beyond the bounds of this drawing, till a second summit is reached at Wayland, at 1,361 feet; then it is a rapid descent into the Genesee Valley at Groveland, 448 feet, and another moderate climb to East Bethany, 1,006 feet, to surmount the watershed which all the other lines also must conquer in getting into Buffalo.

Fig. 3 is the profile of the New York Central Railroad for two of its three main divisions between New York and Buffalo. The contrast between this grade and those of the Scandinavian and Lackawanna railroads is very marked. It is rightly called "the water-level route." There is no ascent all the way to Albany.

From there a sharp ascent followed by a swift descent brings the trains into the Mohawk Valley, which gives an easy grade to Utica and Rome, from which the "long level" of the Erie Canal is duplicated by the long level of the railroad to Syracuse, where the altitude is barely above 400 feet. The highest station on the line is Batavia, 895 feet. The Scandinavian Railway ascends more than four times the greatest altitude reached by the New York Central, and nearly ten times anything reached between New York and Syracuse—for there is a little summit of 467 feet west of Utica—and 80 times the highest point between New York and Albany.

Rochester, N. Y. FREDERIC CAMPBELL.



THE GRADES OF THE BERGEN-CHRISTIANIA RAILWAY

Alloys for Permanent Magnets

IN the investigations of electrolytic iron and its alloys, which have been carried out by C. F. Burgess and J. Aston, and which are described in the *Metallurgical and Chemical Engineer*, it seems that tests were made of the magnetic quality of all the samples. Among these were many which showed low permeabilities and high coercive force, suggesting their utility for permanent magnets rather than as electromagnetic material. Upward of 100 samples were tested for this feature; all of the bars contained Cr, Mn, Mo, Ni, and W as binary alloys or in various combinations together or with other elements. The tests recorded in the paper are for the most part on carbon-free alloys. The results are mainly of value, therefore, as indicating the influence of the various elements in inducing the conditions necessary for a good permanent magnet. They were carried out on an Esterline permeameter. The bars were tested as forged, and after water quenching at 1,000 deg. C. To prevent oxidation of the samples while heating them for quenching a barium chloride bath was used. The quenching at 1,000 deg. C. will probably not have brought out the best qualities of some of the bars, but it was deemed the best general treatment, since with so many bars under test it was impossible to subject each sample to tests for its critical points and special conditions of heating. In addition to these general tests, all bars which showed a fair retentivity and a coercive force above 30 were subjected to a test of their ability to hold residual magnetism after shock. For this test the bar was subjected to the maximum magnetizing force of 200 C. G. S. units, and the retentivity noted when this magnetizing force was reduced to zero. The bar was then removed from the machine, subjected to the disturbing factor, and the retentivity again recorded after reinserting the specimen in the permeameter The two means commonly employed in practice for seasoning permanent magnets were used, viz., jarring or rapping the bar and boiling. For the latter treatment each bar was inserted in a piece of wrought-iron pipe, which served as a shield to prevent the mutual influence of the magnetic fields, and boiled in water for three hours. A large number of trials of the rapping and boiling treatments showed them to be practically equal in their effect. An extensive series of tables is given in the paper, which set forth the main results of the investigations. From the figures it is deduced that Cr, Mn, Mo, and W are the most important elements for use in the manufacture of permanent magnets. The presence of a third element is necessary. While carbon is beneficial, it is possible to obtain highly satisfactory materials either by various combinations of the four above-mentioned elements or by suitable additions of Si or V, the latter, in particular, being very suitable. When the material for the permanent magnet is to be hardened by quenching, the presence of a considerable amount of carbon is desirable.

Effect of Paris Flood on Electrical Machinery

THE effects of the Paris floods on electrical machinery are described by Guery in the Societe Int. Elect. Bull. It seems that a great deal of damage was done by the floods to machinery, both on railways and in central stations; but of these, 16,000 different units have been rendered serviceable, without any rewinding. Everything was first carefully washed, to remove mud, etc.; sometimes a bath of dilute sulphuric acid was used, in cases where injury had been caused by the overflow of acid from accumulators. Some sort of drying process was then adopted, after the windings had been sufficiently loosened to expose them to the air. Some sorts of insulation, such as fiber, press-spahn, and cardboard, were found to be so much deformed as to be useless. Some of the fixed machinery was dried by passing current, but suitable pressures were not always available. Some of the machines were driven at slow speeds, and dried in various ways electrically; and some of the railways treated all their fixed machinery by this method. In some cases the apparatus was dried by stoving, the temperature being kept between 110 and 125 deg. C., never exceeding 130 deg. C.; in other cases much lower temperatures were employed, requiring a much greater length of time. In one case, i. e., that of the State railways, stoving under a vacuum was tried; this seems to have given no result at 65 degrees, a satisfactory result at 75 degrees, but probably a better result at 100 degrees. Some motors were more or less burnt, so far as their insulation was concerned, by passing overheated air through them. It seems to have been found that both heating in air at 106 degrees and in a vacuum at 65 degrees were ineffective. There were many failures with transformers, but in most other cases success was attained, provided no time was lost in beginning work. Underground conductors, supported on glass or porcelain, were, of course, hardly affected, and this was also the case with supports of paraffined wood, used as a third-rail support, though here were a few failures. Some of the older types of rubber cables were found to be useless for high pressures, though serviceable for 110 volts, even after being submerged for twenty days. Paper cables, generally speaking, were little injured, even after their immersion for a month; under heavy pressures of water some damage was done, and the junction boxes were a weak spot. Batteries were found to be very little injured. The paper concludes with some notes as to precautions that may reasonably be taken in future, together with a brief notice of the various incidents of the flood of last year.

Breakwaters on the West Coast of Jutland

The Vornpör and Hanstholm Walls

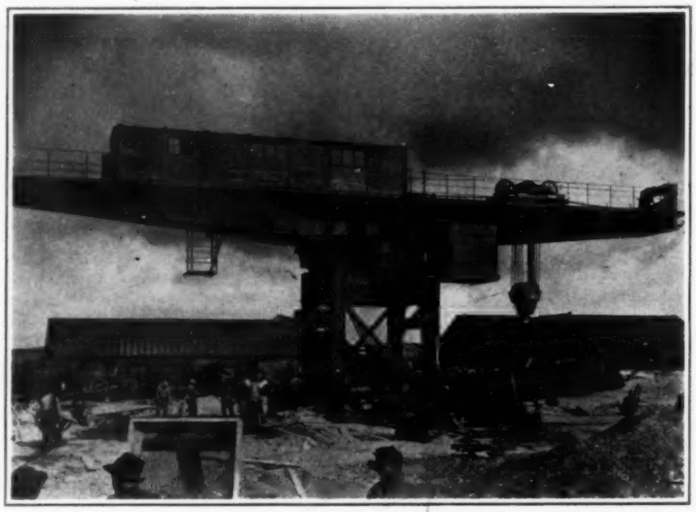
By C. Van Langendonck

Two breakwaters have recently been completed on the west coast of Jutland, one at Vornpör and the other at Hanstholm. The object of the construction is to produce for the fishermen additional safety during their work in beaching their boats in stormy weather, and to prolong the fishing season by enabling the men to go to sea under circumstances which would otherwise make it impossible for them to do so. Both breakwaters form approximately a right angle with the coast, but that at Vornpör has a direction northwest to north, while that at Hanstholm runs due north. There will, consequently, always be shelter at one side of one of the piers.

The breakwaters, which constitute an interesting piece of engineering work, are each 1,000 feet long, and their construction has involved an expenditure of about $500,000. The basis for the contract was the plan worked out by the Danish Water Construction Department, according to which both breakwaters were to consist of concrete blocks of up to twenty tons weight, which were to be placed within a framework of iron on a foundation layer of shingle, laid to level the irregularities in the lime stone underneath. The grooves between the iron frame and the concrete blocks, and between the concrete blocks themselves, were afterwards to be filled with neat cement. The size of the iron boxes was 16 feet in the direction of the length of the breakwaters, while the breadth at the top varied from 20 to 22 feet; the batter on the side was 1:6. An iron box filled with concrete blocks was estimated to weight from 300 to 750 tons. The surface of the iron boxes was to be of the same height as the ordinary water level.

A modified construction was, however, proposed by the contractors, Messrs. F. V. Blom og Saabye and O. Lerche, viz., the adoption of reinforced concrete boxes instead of iron boxes, which were to form the section of the pier, and yet at the same time, like the iron boxes, form the outer casing for the filling, which consisted of concrete blocks. The reason for these alterations was a desire to employ larger concrete blocks and to avoid the use of the temporary iron framework. This suggestion was accepted by the authorities, and the contractors received the option of either entirely or partly building the piers in this manner. These concrete boxes have the same length and breadth as the iron boxes, and a weight of 80 to 90 tons, being divided vertically into three pieces. They are filled with solid concrete blocks of about the same weight. The proportions of the mixture forming the concrete boxes are 1:2:4, and in the solid blocks 1:3:6.

Each of the two breakwaters consists of sixty-two sections, of which the one farthest out stands in about 20 feet of water on a firm limestone bottom. Supposing a section of one of the outer boxes, then the former would consist vertically of three boxes. The interior space is filled with solid blocks and the large intervals between the blocks with small stones averaging about an inch in size, similar stones forming the layer upon which the blocks rest. As soon as the inside blocks were brought into position these intermediate spaces, with the stones, were filled with cement through a pipe, for which provision was made in the corners of the block. In order to prevent the cement from running out into the sea, the bottom was covered with sackcloth nailed to a timber frame, which was molded in the lower side of the bottom box. This sackcloth was fixed by divers as soon as the lowest box section was placed in position and weighed down by stone. An upper monolithic portion of the pier was formed on the top of the boxes, the topmost of which reached to from 1 foot to 2 feet above ordinary water level. Into the upper portion was placed a number of old rails, in the longitudinal direction of the pier. Both the outer sides of the boxes and the upper structure are covered all over with granite facing bedded into the concrete. Outside the breakwater, on both sides and in front of it, is placed a protecting apron in the shape of concrete blocks, 3 feet to 5 feet high, also covered with granite pavement. This is quite necessary owing to the wear and tear from sand and pebbles through the incessant motion of the waves. These protecting blocks have a weight of 8 to 15 tons each, and lie in pairs; in the outer portion there is a triple row. A space, as already mentioned, was left between the shore and the nearest end of the breakwater, so that a current could pass between the breakwater and the land. This gap had, of course, to be bridged. On account of the heavy traffic which had to pass over it, this connecting piece had to be constructed of substantial materials. The transverse beams consist of eight timbers of dimensions varying from 14 by 14 inches to 16 by 16 inches. The rails along which the crane passed lie at 11 feet above the datum line, and all the rails on shore, where the blocks were made, are, of course, at the same level. It was the original plan to build the bridge of wooden piles, but in the whole of the outer section heavy iron piles had to be adopted, as it was found impossible to drive effectively to the limestone bottom.

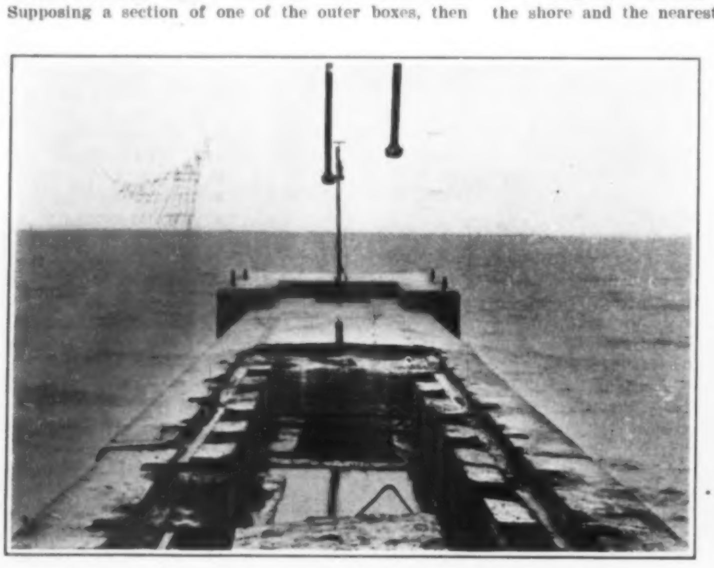


TESTING THE GREAT CRANE WITH A LOAD OF 125 TONS OF RAILS. THIS CRANE IS USED FOR HAULING THE GREAT BLOCKS

The upper structure of the breakwaters was built in the following manner: Concrete blocks, made on shore, were placed on both sides in final position, and the space between these was filled in on the spot with concrete.

The arrangements on shore comprised three casting pits, which formed a right angle with the direction of the pier. The blocks were transported from the casting pits to the rails by means of a Goliath crane. This last placed the block on a truck, which then conveyed it to the crane at the end of the pier.

The work at Vornpör was commenced in the summer of 1904 by constructing the molding pits for the concrete blocks, and the building of the pile bridge to the breakwater, when the placing of the boxes was commenced. In the autumn of 1905 six boxes were laid; in 1906 nineteen; the following year fourteen, in 1908 nineteen, while the two remaining ones were placed in the spring of 1909, when the work upon the upper structure was taken in hand, proceeding from the outer end in the direction of the shore. The Vornpör breakwater was completed in the course of last year (1910). The work has proceeded in a satisfactory manner, and there have been no mishaps. Stormy weather has proved a



THE UPPER PORTION OF THE BREAKWATER IN THE COURSE OF CONSTRUCTION

THE BREAKWATER NEARING COMPLETION

BREAKWATERS ON THE WEST COAST OF JUTLAND

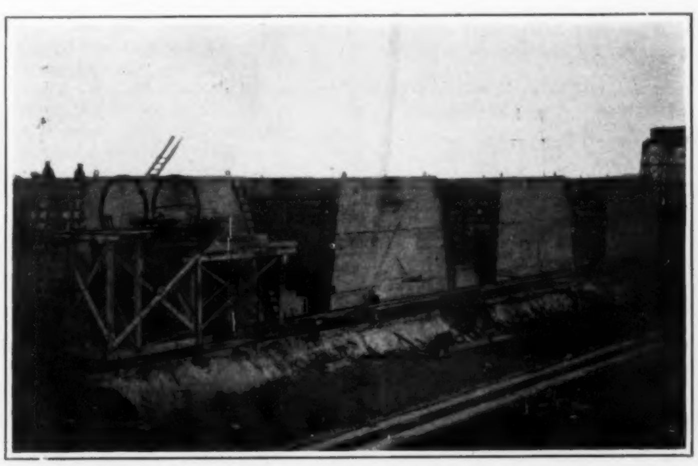
hindrance now and again, and in order to be more independent of turbulent seas, concrete screens, so arranged that they could be used at different depths, were made and occasionally used. They, in a way, answered their purpose, but their practical value was not very great; still they were serviceable in cases of emergency. The building of the Vornpör breakwater has had the unexpected effect that the sea north of the breakwater has made considerable inroads on the shore, both on the foreshore and the more elevated coast, some houses having been washed down.

THE VORNPÖR BREAKWATER NEARLY COMPLETED

At Hanstholm the work was commenced in the spring of 1904. The original scheme with iron boxes was adhered to at this breakwater, as far as the work hitherto done is concerned. The first box was placed in position in April, 1905, and in the course of the same summer eight additional boxes were placed. The work was then discontinued pending the completion of the Vornpör breakwater. Now the heavy plant has been conveyed from there to Hanstholm, and the work will be continued in accordance with the modified system used at Vornpör.

Our photographs represent the different phases of the building of the Vornpör breakwater.

TRUCK FOR CONVEYING THE BLOCKS FROM THE CASTING GROUND TO THE GREAT CRANE



VIEW OF THE CASTING GROUNDS, SHOWING FOUR LARGE CONCRETE BOXES READY CAST AND LINED WITH GRANITE

BREAKWATERS ON THE WEST COAST OF JUTLAND

Production Per Acre Overtaking Population Increase

PRODUCTION per acre is beginning to overtake increase of people, declares the Secretary of Agriculture, in discussing one of the features of his report. "The evidence is very plain that the yields per acre of our crops are now increasing, and if the facts were assembled in detail for the States, it would be found that the percentage of increase in yield of many of them is greater than the percentage of normal increase of population—that is, the increase of births over deaths in the old native element."

That this is a fact, in greater or less degree, is stated comprehensively in the report. During the ten years, 1896-1905, the production of wheat per acre on the average increased over the average of the preceding ten years in a greater degree than the normal increase of population (that is, apart from immigration and the temporarily high birth rate of the foreign born) in twenty-six States, and two more States are all but ready to join them. In fourteen States corn production per acre has increased faster than the normal increase of population, and this is almost true of five more States. The number of States in this list in the case of barley is 21; rye, 30; buckwheat, 19; cotton, 3; potatoes, 24; hay, 35; and more or less States are almost ready to enter this list in the case of all crops.

A demand that is more difficult to fulfill in production per acre is for an increase that equals or exceeds the actual increase of population, including the immigrants and the temporarily high birth rate of the foreign born. But, notwithstanding the fact that this difficulty is greater in the United States than it is in all other countries that have practically ceased to take much new land into cultivation, many of the States of this nation are each maintaining an increase of production in the case of one or more prominent crops that is greater than the actual increase of population. Ten States are doing this in the case of corn for wheat the number is 22; for oats, 16; for cotton and tobacco, 1 each; for rye, 21; for potatoes, 15; and for hay, 25.

We cannot look for any other result than that the yields per acre of all crops shall increase at an even faster rate in the future, in view of the intense interest with which our people are turning their attention toward agricultural improvement. If there are certain forces at work which, if unchecked and made more prevalent, will in the future compel us to bid against the world for food, the counteracting forces have nevertheless been already set in motion, with the promise of increasing effect.

Eradication of Animal Diseases

THE work in cattle-tick eradication resulted in the release from quarantine of 57,518 square miles, the largest area released since the beginning of the work in 1906. The total area so far released is 129,611 square miles in 11 southern states.

Areas aggregating 390,000 square miles, including all of Washington and parts of Oregon, Nevada, Utah, Arizona, and Colorado, were released from the sheep-scab quarantine. A quarantine for this disease was placed on Kentucky. Areas released from quarantine for scabies of cattle amounted to 53,021 square miles. The Department inspected 52,749,920 sheep and 18,190,456 cattle, while 12,153,356 sheep and 1,336,829 cattle were dipped under supervision.

In August, 1909, a quarantine was established because of malignant lip-and-leg ulceration of sheep which appeared in Wyoming. The Department has kept a force of veterinarians in the field to assist sheepmen and state officers in treating the disease and to enforce the quarantine. About one-fourth the quarantined area has been released, the number of cases has been reduced, and the spread of the disease prevented.

For the eradication of tuberculosis among cattle in the District of Columbia the Department arranged to test all cattle in the District with tuberculin, to supervise the slaughter of those that reacted to the test, and to reimburse the owners. Over 18 per cent of the cattle in the District reacted to the test, and of these 98½ per cent showed tuberculosis on post-mortem examination. All cattle brought into the District are now tested; it is also intended to retest the herds at intervals. Continued for a reasonable time this course will completely eradicate tuberculosis from the cattle of the District.

The efficiency of the serum treatment for the prevention of hog cholera, devised by the Bureau of Animal Industry, was strikingly demonstrated in a test at Kansas City. Thirty-five pigs were placed in a pen together, of which 4 had been inoculated with virulent hog-cholera blood, 22 injected with the preventive serum, and 9 not treated. The 4 and the 9 died of hog cholera, while the 22 remained well.

Coal-Dust Experiments at the Pittsburg Experimental Gallery

A PRELIMINARY account of the experiments which are being made by the United States Geological Survey is given by G. S. Rice, in the bulletin of the United States Geological Survey, Paper No. 425.

The gallery in which the tests are carried out was built in 1908. It consists of fifteen sections of riveted steel plates, 6 1/3 feet in diameter, total length 100 feet; each section is 6 2/3 feet long and provided with a lateral window and a relief valve on the top. The gallery is closed at one end by a block of concrete 8 feet in depth; the gun used for igniting the dust is sunk flush into this block. Dust is spread on lateral shelves or blown into the gallery and kept in suspension by the ventilating current (Koerting exhauster and blower connected to every third section), but it does not appear that the stated dust densities per cubic foot of air space were really maintained. Ignition of the various dusts was obtained in all cases, propagation in most cases; like Taffanel, the experimenters believe that the inflammability of the dust is proportional to the percentage of volatile matter present. Experiments in which charges of 2½ pounds of black powder were tamped with dry or with wet coal dust were not decisive; the wet dust sometimes actually yielded longer flames (up to 64 feet long) than the dry dust. When moist pre-heated air was circulated through the gallery for many hours (up to 70) the explosibility of the dust was not decreased before moisture actually settled on the dust. Coal dust mixed and kneaded with water still remained explosive; when the moisture content was raised to about 30 per cent (2 per cent being the natural moisture in the dust), the flame died away after 30 feet. The laboratory experiments on the absorption of oxygen by dust and on the explosive pressures were conducted by J. C. W. Frazer. The chief work in the gallery so far concerns the relative safety of different explosives.

Potash Salts: Light on an International Controversy—II*

Their Uses and Occurrence in the United States

By W. C. Phalen

Concluded from Supplement No. 1839, page 198

GERMAN POTASH SALTS IN THE UNITED STATES.

According to Consul General A. M. Thackara, of Berlin,[1] the American consumption of German potash in various forms embraces more than half of the exported material and nearly 18 per cent of the entire production. But while the great bulk of the potash salts consumed in the United States comes from Germany, that country, on the other hand, is dependent on the United States for a large part of the mineral phosphates it uses.

According to the latest report of the German potash syndicate, the following are the quantities of several potash salts which were handled by its members and exported to the United States in 1908:

Muriate of potash (chloride of potassium or "Chlorkalium") at 80 per cent 288,524 metric tons,[2] of which 105,281 tons were consumed in Germany, 104,048 tons were exported to the United States, and the remainder to other countries. The amount exported to the United States therefore was 36 per cent of the total.

Fertilizer at 80 per cent (muriate of potash), 21,268 metric tons, all of which was exported to Scandinavia and Denmark.

Sulphate of potash (Schwefelsaureskali) at 70 per cent, 54,751 metric tons, of which Germany used 2,821 tons, the United States 26,000 tons (47 per cent), England 4,986 tons, and France 6,110 tons, the remainder being sent to other foreign countries.

Calcined sulphate of potassium and magnesium (double manure salts) at 48 per cent, 33,756 metric tons, of which 16,928 tons, or 50 per cent, were sold to the United States and 15,124 tons to Holland, the remainder being consumed in Germany and other countries.

Crystallized sulphate of potassium at 40 per cent, 665 metric tons, all of which was used in Germany.

Manure salts with 20 per cent, 30 per cent, and 40 per cent K_2O, 284,989 metric tons, of which Germany consumed 171,016 tons, the United States 52,731 tons (18 per cent), Scandinavia and Denmark 24,005 tons, and other countries the remainder.

Calcined kieserite, 668 metric tons, of which 542 tons were used in Germany, and the remainder in various other countries.

Kieserite in blocks, 25,532 metric tons, of which 20,950 tons were consumed in Germany, 2,794 tons (11 per cent) in the United States, and 1,788 tons in all other countries.

Kainite and sylvinite, 2,388,381 tons, of which Germany consumed 1,613,556 tons, the United States 361,322 tons (15 per cent), other countries 413,503 tons.

Carnallite and "Berg-kieserite," 74,385 metric tons, of which 71,403 tons were used in Germany, and the remainder exported.

In the following tabulated statement, compiled from official statistics, are shown the production of potash salts in Germany during 1907 and 1908, the value of the products, and the average value per ton:

Production and value of potash salts in Germany, 1907 and 1908.

	1907		
	Quantity (Metric Tons).	Value	Average Value per Ton.
Kainite	2,624,412	$8,595,846	$3.27
Other potash salts	3,124,956	7,285,426	2.33
Muriate of potash[1].	473,138	12,639,704	26.72
Sulphate of potassium.	60,292	2,217,922	36.79
Sulphate of potassium and magnesium	33,368	631,652	18.92

	1908		
	Quantity (Metric Tons).	Value.	Average Value per Ton.
Kanite	2,589,804	$8,812,426	$3.46
Other potash salts	3,500,635	8,064,630	2.30
Muriate of potash[1].	508,692	13,397,738	26.32
Sulphate of potassium.	55,755	2,037,994	36.55
Sulphate of potassium and magnesium	33,149	663,068	20.00

[1] Including 117,390 tons of manure salts, worth $1,843,786, in 1908, and 83,763 tons of manure salts, worth $1,193,332, in 1907.

* Reprint of a bulletin issued by the U. S. Geological Survey.

[1] Daily Consular and Trade Report No. 3587.

[2] A metric ton is equivalent to 2,204.6 pounds.

FINANCIAL RESULTS OF GERMAN POTASH MINING.

The following statement shows the results of the operations of 21 German potash mines in 1906:

Operations of 21 German potash mines, 1906.

	Capital Stock or Paid-up Assessments.	Amortization and General Reserve.	Net Profits.	Dividends Paid	Per Cent of Capital.
Westeregeln	$1,999,200	$280,592	$415,376	$299,880	15.0
Aschersleben	2,856,000	189,320	307,805	285,600	10.0
Wilhelmshall	440,300	192,067	314,738	285,600	64.8
Gluckauf	476,000	112,039	192,067	285,600	60.0
Hedwigsburg	190,400	82,739	223,322	199,920	105.0
Burbach	723,520	70,770	276,541	190,400	25.9
Salzdetfurth	1,666,000	142,819	277,358	233,240	14.0
Hohenfels	1,063,860	108,452	200,799	171,360	68.1
Rossleben	1,439,900	102,114	150,507	142,800	9.9
Carlsfund	1,142,400	86,215	181,921	154,700	13.5
Hohenzollern	1,142,400	58,991	119,000	119,000	10.4
Justus	1,190,000	83,468	16,639	47,600	4.0
Kaiseroda	690,200	84,951	147,560	142,800	20.7
Beienrode	1,011,500	48,777	142,800	142,800	14.1
Jessenitz	1,190,000	110,466	118,626	95,200	8.0
Wintershall	1,094,800	116,411	147,941	147,941	13.5
Sigmundshall	476,000	28,485	23,555	21,718	5.0
Einigkeit	1,568,865	83,439	118,413	....	.....
Alexandershall	761,280	132,248	216,821	142,800	18.7
Thiestershall	952,000	79,462	84,110	66,640	7.0
Johanneshall	1,428,000	73,331	71,581	....	.....
Total	$23,502,625	$2,267,156	$3,747,570	$3,175,599	......

The above statement shows that the 21 mines earned in 1906 an average profit of 15.9 per cent on the invested capital and declared an average dividend of 13.5 per cent. It can be safely assumed that the works not included in this statement also reached this average, as among them were a number of the most profitable mines and but few of the minor companies.

In discussing the position of the potash industry, as developed by the late potash syndicate, Thackara's report, already cited, gives some interesting information as to the cost of production of the different grades of potash salts, based on expert opinion, it being impracticable, for several reasons, to give the official figures. The following statement shows the cost of production and the foreign and domestic prices of the several grades per metric ton:

Cost of production and prices of potash salts.

	Per Cent K_2O	Cost of Production per Metric Ton.	Price per Metric Ton.	
			Foreign.	Domestic.
Kainite	12.4	$1 547 to $1,904	$4.05 to $4.52	$3.38
Muriate of potash	80.0	11.90 to 17.85	33.80	33.80
Sulphate of potash	90.0	16.66 to 26.18	39.20	39 20
Manure salts	40.0	8.33 to 11 90	15.20	15.50

Except for the 40 per cent manure salts, the costs of producing which are higher, in consequence of the small output, the costs of production of the salts listed above vary between 40 and 60 per cent of the receipts from sales. These figures are based on the normal running time of the works in 1906. In the two years 1907 and 1908 the costs of production somewhat increased. They may at some plants even have passed the maximum of 60 per cent. The costs are still low, however, when compared to those of other mining industries. In coal mining, for example, the costs of production amount to 70 or 80 per cent of the total receipts and are often even greater. These facts explain how the selling policy of the potash syndicate and the comparatively low costs of production have stimulated the establishment of new plants.

OCCURRENCE OF POTASH SALT IN THE UNITED STATES.

Igneous Rocks.

Potash is abundant as a constituent of the rocks which form the crust of the earth. According to F. W. Clarke[1] the percentage of potash (K_2O) in the earth's crust is 3.00, this result being an average of 1,434 determinations made in the laboratories of the United States Geological Survey up to January 1st, 1908. In some varieties of igneous rocks, particularly those rich in the potash feldspars, there is a large amount of potentially valuable potash. The feldspars are widely distributed minerals and comprise about 60 per cent of the earth's crust. Among the igneous rocks containing large amounts of potash are the glasses, of which the chief are obsidian, pumice, perlite, and pitchstone. In these rocks the potash may run as high as 5 or 6 per cent. The rhyolites are also rich in potash. Examples of this rock containing more than 5 per cent of potash are common, and a certain rhyolite from Silver Cliff, Colo., has been shown to contain 8.38 per cent.[2]

[1] Bull. U. S. Geol. Survey No. 419, 1901, p. 27.

[2] Cross, Whitman, Proc. Colorado Sci. Soc., December 5th, 1887, p. 229.

The trachytes and phonolites are also rich in potash, consisting chiefly of that variety of potash feldspar (orthoclase) known as sanidine. Some of these rocks are known to contain nearly 8 per cent of potash. Among the granitoid rocks should be mentioned granite, monzonite, and syenite, which contain considerable amounts of the potash feldspars. The leucite rocks of the Leucite Hills, Wyoming, contain, so far as known, the largest amount of potash among the igneous rocks. These rocks have been described by Whitman Cross, of the United States Geological Survey.[1] Certain of them, wyomingite and orendite, contain from 9.81 to 11.91 per cent of potash (K_2O). In many localities there occur large dikes or deposits of more or less pure feldspar, commonly orthoclase, which run much higher in potash than the ordinary granite rocks and may approach the theoretical potash content of pure orthoclase feldspar—16.8 per cent of potash. Such deposits have been developed in the New England States, Pennsylvania, New York, and Maryland, where they have been mined extensively and the feldspar ground to fine powder, principally for use in pottery manufacture. These deposits may constitute in themselves a comparatively high-grade fertilizer were the potash all available for plant food. As the feldspar for use in pottery making must be almost entirely free from mica or iron-bearing minerals, large quantities of such potash-rich material are rejected at every quarry. But the potash of these rocks, even when thus finely ground, has been generally supposed to be tightly locked up, being practically insoluble by any known cheap commercial process. Ten, eight, or even five per cent potash rock, of which there are millions of tons well distributed over the globe, would be highly valuable as a fertilizer were there any known cheap method of making the potash available for immediate use to the growing plant.

Experiments have been made by the United States Department of Agriculture[2] for the utilization of this potash supply through fine grinding or pulverizing the feldspathic rocks in a manner similar to the grinding for pottery. So far as known these experiments have not been completed and the results thus far attained have not proved conclusive. This source of potash has also been investigated by individuals, among whom may be mentioned Dr. A. S. Cushman, formerly assistant director of the Office of Public Roads, who, on April 30th, 1907, took out patent No. 851,822 for a process for the extraction of potash, soda, and other soluble bases from ground rocks. This patent is described as follows:[3]

"Feldspathic or other potash-bearing rock is ground to fine powder, slimed with water, and placed inside of a suitable wooden container, which is then set inside of another larger vessel. Water is now placed in the outer vessel and electrodes inserted so that the inner or slime chamber becomes connected with the positive pole and the outer chamber with the negative pole. A current of electricity from a dynamo is then turned on. When this is done the potash, soda, and other soluble bases are partially set free from the combinations with alumina and silica in which they exist in the feldspathic rocks.

"Under the influence of electrolysis the soluble bases pass through the wooden partition and the water in the outer vessel becomes alkaline, owing to the accumulation of potassium and sodium hydroxide. The electrical resistance of the cells arranged in this way is so high that only a small fraction of an ampere passes through under a potential of 110 volts. After a certain percentage of the alkali has been extracted in this manner, the action slows down, and it has been found necessary to devise methods to accelerate it.

"Dr. Cushman has discovered two methods of accelerating the decomposition of the rock slime and hastening the extraction of the potash. (*a*) By a suitable grinding or churning arrangement the slime in the inner chamber can be kept in a continual agitation, which causes the necessary reactions to go on more rapidly. (*b*) If a small quantity of hydrofluoric acid is added to the slime a very great acceleration in the rate of decomposition and extraction is obtained, and it is possible in a reasonably short time

[1] *Am. Jour. Sci.* 4th ser., vol. 4, 1897, p. 130.

[2] U. S. Dept. Agr., Bur. Plant Industry, Bull. 104, 1907.

[3] Chem. Engineer, vol. 5, 1907, p. 21; Bur. Census, Bull. 92, 1908, p. 39.

to make a complete extraction of all the potash contained.

"If instead of caustic potash it is desired to make various salts of potash such as are in ordinary use for fertilizers and other purposes—that is, nitrate, sulphate, chloride, and phosphate—the corresponding acids (nitric, sulphuric, hydrochloric, and phosphoric) are fed in a dilute form into the outer or so-called cathode chamber fast enough to neutralize the caustic alkali as it forms. By varying the amount of acid added the resistance of the cell can be controlled and the decomposition of the rock carried on under the best and most economic conditions."

Greensand Marls of New Jersey.

Potash is found in river waters, but in smaller quantities than soda (Na_2O). The difference is still greater in ocean water, owing to the fact that the potash for some unknown reason is largely taken up by the sediments, forming glauconite, while the soda is largely held back in solution. This glauconite is an important constituent of the greensand marls of New Jersey.

About 30 years ago the greensand marls of the southern portion of New Jersey were in great demand. On the first geologic map of that State the location of the marl beds was shown, and in some of the earlier reports the deposits were described and numerous analyses given, as well as instructions in the use of the marl. In recent years, however, marl has been supplanted to a large extent by the more highly concentrated artificial fertilizers and is no longer dug extensively.

The following analyses show the composition of the different grades of marl as dug and applied to the soil. The glauconite or greensand in them is of nearly uniform composition, but mixed with it are carbonate, sulphate, and phosphate of lime, quartz sand, sulphide and phosphate of iron, shells, etc. The differences in the kind and quantity of these substances cause wide differences in the appearance of the marl containing them, as well as in its composition and properties.

The following table gives the potash and phosphoric acid content, in percentages, of typical specimens of New Jersey marl:

Potash and phosphoric acid in typical greensand marl of New Jersey.

	1	2	3	4	5
Phosphoric acid....	1.14	1.33	1.02	2.24	2.69
Potash.....	5.65	5.67	6.32	5.18	6.31

	6	7	8	9	10
Phosphoric acid...	2.56	3.58	3.87	2.58	2.30
Potash............	4.02	3.75	4.11	4.25	3.53

New Jersey marl[1] has been of incalculable value to the region in which it is found. It has raised this region from the lowest stage of agricultural exhaustion to a high state of improvement. Found in places where no capital and but little labor were needed to get it, the poorest people have been able to avail themselves of its benefits. Lands which in the old style of cultivation had to lie fallow, by the use of marl produce heavy crops of clover and grow rich while resting. Land which had been worn out and left in common are now by the use of this fertilizer yielding large crops of the finest quality. Everywhere in the marl district may be seen farms which in former years would not support a family, but which are now making their owners rich through their productiveness. Bare sands by the application of marl are made to grow clover and then crops of corn, potatoes, and wheat. "Pine barrens" by the use of marl are made into fruitful land. The price of land in the greensand-marl belt of New Jersey was considerably below that in the northern part of the State 40 years ago; now that the lands are improved their price is higher than that of lands in the northern part of the State.

A recent invention[2] proposes to use glauconite or greensand (such as is found in New Jersey) as a principal ingredient in the manufacture of hydraulic cement. In making the cement the potash of the greensand would be volatilized at the temperatures employed and its recovery as a by-product would be possible.

Salines.

The known occurrences of potash salts in the United States are few in number. Those which are known and which promise results are confined to certain arid portions of the Western States. Here the structural conditions are favorable for the retention of any salines that may have been deposited, and the presence of alkaline lakes suggests the possibility that others may once have existed and are now covered by later deposits, their saline content being concealed. Though potash salts occur in this region

[1] From Ann. Rept. State Geologist of New Jersey, 1886.

[2] Patent 912266, dated February 9th, 1909.

in the waters of the alkaline lakes, it has yet to be proved that these waters contain a commercially valuable quantity of potash salts. An idea of the quantity of potash salts in the waters of some of these lakes may be obtained from the figures given in the following tables.[1] Though the waters of these lakes have never been utilized for their content in potash, it appears as if they would prove of some commercial value. It must be admitted, however, that the German deposits are unique, not so much in the quality of the salts contained in them as in the quantity and in the fact that the overlying geologic formations are such that they have been kept intact so far as known, a condition which is as important as the deposition of the original material itself.

Potash salts occur in the water of Owens Lake, Inyo County, Cal. This lake at the present time has no outlet, and on the completion of the Los Angeles aqueduct will be deprived of the greater part of the drainage hitherto tributary to it. Its ancient shore line, nearly 200 feet above its present level, indicates that at one time it had an outlet to the south and was there joined to a chain of lakes. Its waters are strongly alkaline and the principal salts contained in them are the chloride and carbonate of sodium. A number of analyses, more or less complete, have been made of its water. These vary according to the conditions under which the samples were collected and the analyses made. The dilution of the water of this lake after storms in the surrounding mountains and its concentration at the end of summer explain in part differences in the analyses. One of the first analyses of water from this lake is as follows:

Analyses of water of Owens Lake.

	Grains per imperial gallon.
Sodium chloride	2,942.15
Sodium sulphate	956.80
Sodium carbonate	2,914.43
Potassium sulphate	35.74
Potassium silicate	139.54
Organic matter	16.95

The following analyses are comparatively recent:

Analyses of water of Owens Lake.

[Grammes per Liter.]

	1	2
Silica	0.220	0.1721
Iron and aluminium oxides	0.038	......
Calcium and magnesium carbonates	0.065	......
Sodium borate ($Na_4B_4O_7$)	0.475	......
Potassium chloride	3.137	......
Sodium chloride	29.415	23.2890
Sodium sulphate	11.080	9.2907
Sodium carbonate	26.963	24.4080
Sodium bicarbonate	5.715	......
Potassium sulphate	..	6.4487
Total	77.078	63.6025

[1] T. M. Chatard, analyst, Bull. U. S. Geol. Survey No. 60, 1890, p. 58.

[2] Oscar Loew, analyst. Ann. Rept. Geog. Surveys W. 100th Mer., 1876, p. 190.

Analysis No. 1 gives the following composition of the dried salts:

Analysis of dried salts from Owens Lake.

	Per cent.
Silica	0.28
Iron, alumina, lime, magnesia	0.13
Sodium biborate (borax)	0.63
Potassium chloride	4.07
Sodium chloride (salt)	38.16
Sodium sulphate	14.38
Sodium carbonate	34.95
Sodium bicarbonate	7.40
	100.00

The waters of this lake also contain a small quantity of lithia, phosphates, and nitrates. The specific gravity of the water is 1.051.

Analyses of the crude soda formed by solar evaporation of the water of this lake gave Chatard the following results:

Analyses of soda from evaporation of water of Owens Lake.[1]

	1	2	3	4	5	6
Water	20.87	14.51	4.33	3.43	2.24	11.03
Insoluble	1.55	0.078	.	...	....	. .
Organic matter, silica, alumina and lime and magnesium carbonates	0.37	0.237	0.09	0.06	0.06	0.18
Potassium chloride	0.51	1.07	1.12	1.14	1.21	2.93
Sodium chloride	3.51	7.44	35.06	45.59	60.99	19.16
Sodium sulphate	1.89	3.18	25.44	26.70	19.01	5.70
Sodium carbonate	40.87	43.75	22.84	18.19	12.51	55.04
Sodium bicarbonate	30.65	30.12	10.53	4.06	3.88	4.09
Sodium biborate	..	....	.	....	..	2.01
Totals	100.22	100.885	99.41	99.17	99.90	100.14

[1] Bull. U. S. Geol. Survey No. 60, 1890, p. 63.

From these analyses and from data similar to those given beyond in connection with Mono Lake it is estimated that Owens Lake contains, among other constituents, 8,000,000 tons of potassium sulphate, together with large quantities of sodium carbonate, common salt, and borax. These materials are, however, present in such dilute solution that they have not been utilized up to the present time. The diversion of Owens River, however, must gradually result in a notable increase in the alkalinity of Owens Lake and the conditions for the utilization of the potash salts will become more favorable.

[1] Bailey, Gilbert, Bull. California State Min. Bur. No. 24, 1902, pp. 94 *et seq.* Chatard, T. M., Bull. U. S. Geol. Survey No. 60, 1890, pp. 27-101.

At Owens Lake the manufacture of sodium carbonate has been carried out on a commercial scale. In order to determine the most favorable conditions for the process, Chatard subjected a quantity of the water to fractional crystallization and analyzed the salts which were successively deposited. Two concordant series of experiments were made, together with a less complete but corroborative set with water from Mono Lake. The results of the first group were as follows:

Analyses of salts deposited by fractional crystallization of water of Owens Lake.[1]

A. The natural water of Owens Lake. Specific gravity, 1.062 at 25 degrees. Salinity, 77.098 grammes per liter.

B. First crop of crystals. Water concentrated to one-fifth its original volume. Specific gravity of mother liquor, 1.312 at 27.9 degrees.

C. Second crop of crystals. Specific gravity of mother liquor, 1.312 at 25 degrees.

D. Third crop of crystals. Specific gravity of mother liquor, 1.315 at 26.25 degrees.

E. Fourth crop of crystals. Specific gravity of mother liquor, 1.327 at 35.75 degrees.

F. Fifth crop of crystals. Specific gravity of mother liquor, 1.300 at 13.9 degrees. This crop was obtained by chilling the solution in order to determine the effect of cold.

	A[2]	B	C	D	E	F
H_2O	...	14.51	4.33	3.43	2.24	11.03
Na_2CO_3	34.45	43.75	22.84	18.19	12.51	55.04
$NaHCO_3$	7.40	30.12	10.53	4.06	3.88	4.09
Na_2SO_4	14.38	3.18	25.44	26.70	19.01	5.70
NaCl	38.16	7.44	35.06	45.59	60.99	19.16
$Na_2B_4O_7$	0.63	...	.	.	....	.....
$NaCO_2$	.....	...	...	...	. .	2.01[3]
KCl	4.07	1.07	1.12	1.14	1.21	2.93
$(CaMg)CO_3$	0.88	0.14			....	.....
$(AlFe)_2O_3$	0.05	0.01	0.09	0.06	0.01	0.02
SiO_2	0.28	0.055			0.05	0.16
Organic matter	.	0.082			.....	.....
Insoluble	.....	0.078		.....	.....	....
Totals	100.00	100.385	99.41	99.17	99.90	100.14

[1] Clarke, F. W., Bull. U. S. Geol. Survey No. 330, 1908, p. 192.

[2] Composition of the anhydrous residue.

[3] Chatard supposes that the biborate could not exist in so strongly alkaline a solution as the mother liquor from which this crop was obtained.

Mono Lake is situated in Mono County, Cal., near the Nevada line, at an elevation of 6,730 feet, the highest level above the ocean of all the saline lakes of the Great Basin. Its water is dense and alkaline. At this lake the alkaline carbonates are abundant, owing to the volcanic rocks of the lake basin, as shown by the complete analysis made by T. M. Chatard, as follows:

Analysis of water of Mono Lake.

	Grammes per liter.
Silica	0.0700
Calcium bicarbonate	0.0810
Magnesium bicarbonate	0.3349
Potassium chloride	1.8342
Sodium chloride	18.5068
Sodium sulphate	9.8690
Sodium carbonate	18.6720
Sodium bicarbonate	3.9015
Sodium biborate	0.2000
Alumina	0.0030
	53.4724

The results of this analysis show that chloride of sodium and carbonate of sodium constitute nearly 35 per cent each of the total solids. Experiments by Chatard on the fractional crystallization of the mineral content of the water gave the results presented below, which show the same general rule of deposition as at Owens Lake. The water used in the experiments had already been evaporated to about one-sixth of its original volume and had a specific gravity of 1.210. The analyses are as follows:

Analyses of salts deposited by fractional crystallization of water of Mono Lake.

	1	2	3	4	5
Water	12.28	10.98	0.69	4.18	11.31
Silica	0.07	0.17	0.16		0.13
Calcium Carbonate	0.05	0.14	0.05	0.07	0.02
Magnesium carbonate	0.48	0.46	0.02	....	.
Potassium chloride	0.69	0.69	0.47	0.71	15.20
Sodium chloride	19.18	21.34	29.96	60.75	32.36
Sodium sulphate	2.73	14.18	49.13	16.22	6.65
Sodium carbonate	36.87	41.07	18.27	14.22	33.69
Sodium bicarbonate	27.37	10.99	10.03	3.98	0.49
Totals	99.72	100.02	99.78	100.03	99.85

The lake has an area of 85.5 square miles and an average depth of 61.5 feet. From these figures its

volume has been calculated. From its volume and the mineral content of its water the amount of the various salines which it contains has been estimated. The results, which are of interest, indicate the presence in the lake of 10,538,100 tons of potassium chloride. Such figures show that the saline reserves in this and other incompletely evaporated or playa lakes of the desert regions of California and other public-land States are very large and may prove valuable when transportation facilities have been developed and methods for the extraction of the salts perfected. Potassium nitrate has been found in the desert region northeast of Salton, Riverside County, Cal.

Alunite.

Near the close of the year 1910 Mr. A. E. Custer, of Salt Lake City, Utah, sent to the United States Geological Survey a specimen of alunite (hydrous sulphate of potash and aluminium, $K_2SO_4.3Al_2(SO_4)_3.6H_2O$) of a very unusual type. The occurrence is reported to be located near Richfield, Sevier County, Utah, close to the railroad. The deposit varies from 6 to 10 feet in thickness.

An occurrence of scientific and economic interest is the association of alunite and gold in the Goldfield district of Nevada. F. L. Ransome,[1] of the United States Geological Survey, believes that the composition of the ores and the changes exhibited in the country rock point to hot ascending solutions as the agent which has produced the alunite. On some of the ore dumps the partly soluble sulphate is present in sufficient quantity to suggest its removal by leaching. Before undertaking such a step several factors must be considered, such as quantity of raw material, proximity to market, transportation facilities, and freight rates.

POSSIBLE OCCURRENCE OF POTASH SALTS IN THE UNITED STATES.

To make a thorough and complete investigation of the occurrence of potash salts in the United States, every known salt deposit should be tested, for ordinary rock salt may overlie soluble potash salts as well as underlie them. Both these conditions exist at Stassfurt. The normal occurrence of salt is, however, at the base of a series of soluble salines deposited from the evaporation of sea water. The deposits of Midland and Isabelle counties, Mich., are of interest in this connection, inasmuch as they contain bromine in commercial quantity, a fact which indicates partial desiccation of sea water and the occurrence of mother liquors. The salt deposits of Mason County, W. Va., and adjacent parts of Ohio likewise contain and are worked for bromine.

[1] Econ. Geology, vol. 2, No. 7, 1907, p. 689; Prof. Paper U. S. Geol. Survey No. 66, 1909.

The red beds of the southwestern part of the United States, in Texas, Oklahoma, Kansas, Colorado, New Mexico, and possibly other States, contain deposits of gypsum and salt and are worth notice as possible sources of potash salts. These beds might profitably be explored in those places where structural conditions seem to favor the accumulation and retention of the salines.

ORGANIC SOURCES OF POTASH SALT.[1]

The organic sources of potash salts are wood ashes, beet-sugar molasses and residues, wool scourings (suint), and sea weed.

Wood Ashes.

Land plants take up considerable quantities of potassium compounds from the soil. When the plants are burned, about 10 per cent of the weight of the ash is potassium carbonate, which may be obtained by lixiviation. Potash from wood ashes is now made chiefly in Russia, Sweden, and America, the woods most employed being elm, maple, and birch. Sometimes the stumps and small branches only are burned, the trunks being used for timber. The ashes are moistened slightly, put into tanks having false bottoms on which straw is spread, and then lixiviated with warm water. The lye so obtained is evaporated (sometimes by the waste heat from the burning wood) in iron pots until it solidifies on cooling. The dirty brown mass is then calcined in a reverberatory furnace until all the organic matter is destroyed. The product is known as potash or crude pearlash. It is white or gray in color, and contains about 70 per cent of K_2CO_3, with some potassium sulphate, potassium chloride, and sodium salts. By redissolving the crude potash in water and settling and concentrating the solution until the sulphate and chlorides separate as crystals, a concentrated and fairly pure lye is obtained. When this is evaporated to dryness and the residue calcined, it yields a much purer product, known as refined pearlash, containing from 95 to 97 per cent of K_2CO_3. It is necessary that low heat be employed in the calcination, for the charge fuses at a moderate temperature.

Quicklime is often put in the bottom of the tanks before the ashes are introduced. On leaching, the solution of potassium salts reacts with the lime, forming insoluble calcium salts and yielding more or less potassium hydroxide in the lye. The resulting product is a mixture of potash and caustic potash.

Beet-sugar Molasses and Residues.

In the manufacture of beet sugar a very impure molasses remains, containing among other things a large amount of soluble potassium salts. This molasses is now generally fermented, and in that process the sugary substances are converted into alcohol, which is distilled off, leaving the mineral salts in the liquid residue, called "vinasse" or "schlempe." If this is evaporated to dryness and the mass calcined, the organic potassium salts are decomposed, leaving in the cinder about 35 per cent of potassium carbonate and a large amount of chloride and sulphate, together with sodium salts.

[1] Taken in part from Thorp, F. H., Outlines of industrial chemistry, 1901, pp. 130 *et seq.*

Wool Scourings (Suint).

Wool scourings furnish some potash in countries where much wool is washed. Sheep's wool as it comes from the animal contains from 30 to 75 per cent of its weight in impurities, consisting of dirt, sand, dung, etc.; wool grease or "yolk," a fatlike substance, made up of cholesterine and compounds in which it is associated with oleic, stearic, and palmitic acids; and "suint," which consists chiefly of potassium salts of oleic, stearic, and other organic acids, with small quantities of chlorides and sulphate and nitrogenous matter. The "suint" exudes from the animal in the perspiration and is deposited on the wool by evaporation. It is soluble in cold water and is thus removed in the scouring process. If the wash waters containing wool grease and suint are run into streams, pollution of the water results. The desirability of preventing this nuisance, as well as the value of the potash, has resulted in attempts to dispose of the washings in some economical manner, and they are usually evaporated to dryness and calcined. When the material is calcined in closed retorts, a considerable quantity of ammonia is obtained. The cinder is then lixiviated and on evaporation the solution yields, first, chlorides and sulphates of potassium and sodium, and finally a very pure potash which averages a little less than four per cent of the weight of the raw wool scoured.

This mode of utilizing wool grease and suint is mainly practiced in France, Belgium, and Germany, and in these countries it is done chiefly to prevent the pollution of the streams. Cheap fuel is very essential to a successful working of the process. On a small scale it can not be carried on profitably, and the wash waters are often run onto the fields as fertilizer.

Potash in Seaweeds.

A concentration of potash salts from sea water is reported as being effected by the giant seaweeds of the California coast. These plants, on drying, are said to exude nearly pure potassium chloride, and its recovery on a commercial scale has been suggested, but so far as known has not yet been actually tried. It is understood, however, that some potash is recovered from kelp elsewhere.

A New Method of Exploring the Earth's Interior

By Dr. Schames.

For information concerning the nature of the earth's interior we have hitherto been dependent entirely upon the study of the propagation of earthquake waves. If we suppose a plane to be passed through the earth's center and any two points of its surface, as A and B

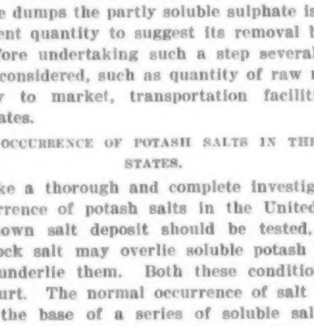


Fig. 1.—Earthquake Shock Travels from A to B by Three Paths, Indicated by the Arrows

(Fig. 1), this plane will intersect the surface in a great circle. It has been learned by experiment that a shock originating at or beneath the point A is transmitted to B by three distinct waves, which reach B at different instants. It is assumed that one of these waves is propagated through the earth's interior, approximately in the straight line AB, and that the other two waves travel through the earth's crust in opposite directions, following the curved paths indicated by the arrows. The observed differences in the times of arrival of the three waves at B, support Wiechert's hypothesis that the earth is composed of a metallic nucleus of density 8.4, surrounded by a shell of rock, about 1,000 miles thick, of density 3.4.

Loewy and Leimbach have recently described two very different and more promising methods of exploring the earth's interior. These new methods are based on the properties of electric waves, which traverse insulators without diminution of intensity, but are partly reflected and partly absorbed by good conductors of electricity. Dry soil and rock may be regarded as insulators, while subterranean water courses, coal seams and deposits of metallic ores and salts are good conductors.

The first of the new methods is based on the reflection of electric waves, and is applicable to depths of about 3,000 feet or less. Electric waves emitted by an inclined antenna at A (Fig. 2) are reflected, by a water course, coal seam or other conducting mass in the position indicated by M, to the point B, which is found by exploration with a receiving apparatus.

The second method is based on the absorption of electric waves, which are emitted by antennæ placed in borings about 1,000 feet deep and are received by apparatus placed in similar borings. If waves emitted from the boring A (Fig. 3) are received in B, but not in C, the inference is that the waves are absorbed by a water course or other conductor between A and C. By this method the earth can be explored to a depth much greater than that of the borings for, owing to the curvature of the earth's surface, the middle point of the straight line which joins the bottoms of two borings, which are 1,000 feet deep and 200 miles apart, lies more than 3,000 feet below the surface. Electric waves which have traveled 250 miles through the earth can be detected, in the absence of any impediment to their propagation. The feasibility of this method has been proved by practical experiments in a German potash mine.

It is obvious that these new methods can be employed

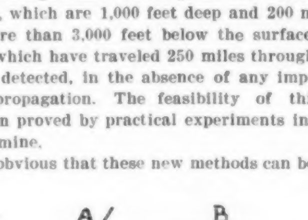


Fig. 2.—Electric Waves Reflected by Underground Stream

for proving or disproving the existence of Wiechert's metallic earth-core, when the reach of subterranean signaling by electric waves has been increased to about 1,250 miles.

An application of more immediate practical utility would be the systematic exploration of large territories for underground water. The great plain of Hungary could be thus explored by means of 48 borings, each 1,000 feet deep. The total cost of the 48 borings would not exceed $110,000, while a single boring, 3,300 feet deep, would cost about $7,500. This method of exploration is especially well suited to tropical regions where the soil is drier, and consequently a better insulator, than elsewhere. According to Wohltmann, many subterranean water courses must lie hidden be-

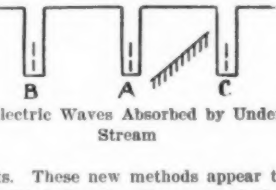


Fig. 3.—Electric Waves Absorbed by Underground Stream

neath deserts. These new methods appear to be eminently well fitted for the discovery of these water courses, and indirectly for the conversion of deserts into clusters of green oases, watered by artesian wells. —*Umschau.*

The Photographic Plate

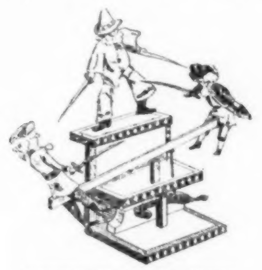
In the *Journal of Physical Chemistry*, W. D. Bancroft states that the silver bromide grain is a complex of silver bromide, gelatine, and water. The process of ripening consists in changing the composition of the silver bromide grain toward an unknown optimum concentration. There is no necessary connection between sensitiveness and coarseness of grain. Chemical and optical sensitizers are depolarizers. Gelatine acts as an emulsifying agent and as a sensitizer, whereas collodion apparently acts only as an emulsifying agent The peptonization of silver bromide is merely a particular case of the general problem of the peptonization of any precipitate. The peculiarities of mixtures of AgCl, AgBr, and AgI can all be explained on the assumption that each of these salts can form a continuous series of solid solutions with either of the two. This is known to be the case for AgCl and AgBr. It seems theoretically possible (by incorporating a suitable depolarizer or sensitizer with the silver bromide grain and using a suitable developer) to make an almost infinitely fast plate having a very fine grain.

New Toys*

Interesting French Inventions

A THREE-HANDED DUEL.

The novel French toy shown in the illustration may appropriately be called a three-handed duel. The two assailants against whom the clown is forced to defend himself are mounted on a see-saw which is operated

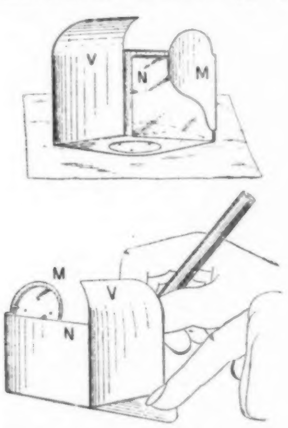


THREE-HANDED DUEL

by pressing alternately the two levers which project from the base. The clown is armed with two swords and the combat continues until the owner of the toy wearies of the sport.

THE MAGIC DRAWING BOARD.

The difficulty which is encountered in attempting to trace a line or to follow a motion which is seen by reflection from a mirror is strikingly illustrated by a new toy, called the magic drawing board. In New York such boards have been sold for some time under the name "Wiggle-waggle Graph." As the diagrams show, the drawing board is really an incomplete box, which lacks one side and has no top. The remaining side *N* and the end *M* are lined with mirrors. The end *V* is made of sheet zinc and its upper part curves

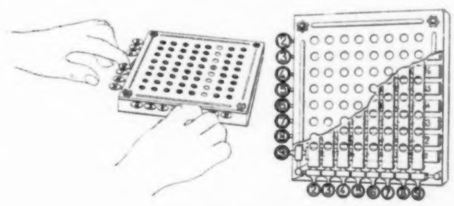


THE MAGIC DRAWING BOARD

over the box and prevents the draftsman, who faces this end, from seeing directly into the interior. A large round hole is cut in the bottom of the box, which is also of sheet zinc. The box is placed on a sheet of paper on which three equidistant dots are marked, just inside the circular aperture. The draftsman, facing the end *N*, sees these dots, as well as his pencil point, only by double reflection from the mirrors *N* and *M*. His task is to join the points by straight lines within a given time. The problem may be varied by increasing the number of dots, or by requiring the drawing of lines that do not meet, but even in its simplest form it requires for its solution a steady hand, a quick and correct eye, a cool head and much patience and practice.

THE PYTHAGORAS; A MATHEMATICAL TOY.

The Pythagoras is a toy, rather than a calculating machine. Its inventor makes no greater claim for it than its utility in teaching children the multiplication table by a pleasant and entertaining method. The apparatus is a flat, square box, the cover of which is perforated by 64 round holes, arranged in square order. The drawing of the apparatus shows eight keys marked with the digits from 2 to 9 on the left side of the box, and also on the front. By depressing simultaneously one key of each series, the product of the numbers marked on the two keys appears in the round hole which corresponds to their intersection. For example, if key 5 on the left side and key 7 in front are depressed, the number 35 appears in the sixth hole of the fourth row. The mechanism by which these results are accomplished is very simple. Each of the keys at the left side of the box is connected with a horizontal strip of paper marked with eight of the required sixty-four products, and each of the front keys is connected with a strip of metal pierced with eight



THE PYTHAGORAS

holes, equal in size to the holes in the lid of the box. When none of these keys is depressed, neither these holes in the metal strips, nor the numbers on the strips of paper are vertically beneath the holes in the lid. Depressing the left-hand key brings the required number, as well as seven others, under holes in the lid, but these are still covered by the metal strips until the depression of one of the front keys brings the hole in one of these strips under the hole in the lid and thus reveals the required product, which is directly beneath both of these holes.

NEW FRENCH FLYING TOYS.

The popular interest in aviation is reflected in the number of flying toys offered for sale in Paris and elsewhere. Three of the newest of these toys are here pictured. The Aeromains (Fig. 1) is a little four-bladed screw propeller, cut from a thin sheet of celluloid. It has a hole at its center and is operated by placing it on a peg and a little celluloid disk at the end of a rod, and rolling the rod rapidly between the hands, as the illustration shows. The rapid rotary motion thus imparted to the light propeller causes it

Fig. 1.—THE AEROMAINS

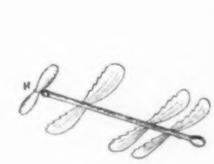


Fig. 2.—THE DEMOISELLE

to rise in the air, and lively sport will be afforded by the attempt to catch it on the rod as it settles down again. The Monte-au-ciel (Fig. 3) is of similar construction, but the propeller is stiffened by a rim and is launched by pulling a cord wound round the rod, which occupies the interior of the hollow handle of the toy. Hence it rises much higher than the hand-driven propeller.

The Demoiselle (Fig. 2) is a real monoplane, with

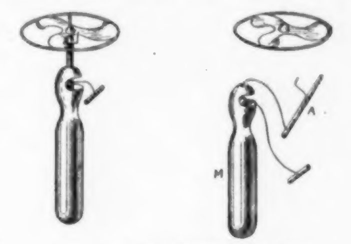


Fig. 3.—THE MONTE-AU-CIEL.

a screw propeller *H*, which is attached to a stout India rubber cord concealed in the tubular axis. This cord is twisted by turning the propeller through about a hundred revolutions. The demoiselle is held, in the inclined position shown in the illustration, with one hand, while the propeller is held with the other. The propeller and the frame of the machine are then released simultaneously. The untwisting of the elastic cords spins the propeller rapidly and the demoiselle, if properly launched, accomplishes a long flight. An interesting aviation contest may be carried out with a number of demoiselles and as many players.

A MACHINE FOR WINDING UP TOY AEROPLANES.

Toy aeroplanes, which are now offered in great number and variety, are usually driven by twisted rubber cords. The aeroplane is wound up by turning the

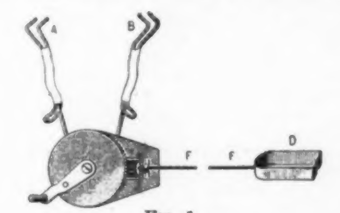


Fig. 1

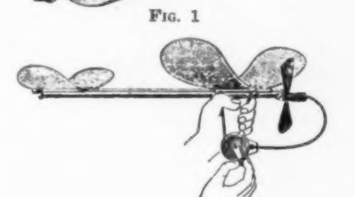


Fig. 2

A MACHINE FOR WINDING UP TOY AEROPLANES

propeller backward through from 150 to 300 revolutions, according to the length of the elastic cord. This operation is tedious, and when the aeroplane is nearly wound up it is not easily kept in the proper position for launching.

The winding is greatly facilitated and accelerated by the employment of the little machine herewith illustrated. The aeroplane is held by grasping its frame with the jaws *A* and *B* (Fig. 1) of a pair of pincers attached to the machine, which consists essentially of a pinion driven by a crown wheel and crank. A flexible transmission, *F F*, connects the pinion with the spring clamp *D*, by which the propeller shaft is grasped. The method of using the machine is shown in Fig. 2. The flexible transmission is so constructed that it forms a loop and stops the operation when the torsion attains a certain value, less than the elastic limit of the India rubber, which is thus safeguarded against rupture.

* Collected from *La Nature*.

Legal Operations of the Department of Agriculture

Cases reported to the Attorney-General for prosecution under the several laws administered by the Department of Agriculture numbered 1,738, twice as many as the year before. More than $40,000 in fines and costs were assessed; hundreds of tons of misbranded foods and drugs were forfeited.

Food and drug cases numbering 990 were reported, 766 for criminal action and 224 for seizure proceedings. Of criminal cases, 246 resulted in convictions, 3 in verdicts for defendants, 96 were dismissed, 152 were pending in courts at the close of the year, and 252 remained under consideration for future action. No leniency was shown in cases involving unfit foods or dangerous drugs. Sixty cases left over from previous years were terminated. The total of fines collected under the food and drugs act during the year was $11,049.31. Of the cases reported for seizure proceedings, 132 resulted in forfeiture decrees, while 50 were pending at the close of the year. In addition 43 shipments were forfeited under seizures of previous years.

Since January 15th, 1910, when the law work of the Forest Service was placed immediately under the solicitor, 105 cases were reported for prosecution under the acts protecting the national forests, while 565 cases of contested claims to lands within the forests were disposed of.

Under the twenty-eight-hour law 438 cases were reported, more than twice as many as during the preceding year; in 139 cases closed $16,500 in penalties was recovered, with $2,919.35 costs; 19 cases out of 158 tried resulted in favor of defendants; 29 cases were dismissed for insufficient evidence; 559 cases were pending at the close of the year. "To carry out the present intent of Congress in passing the act, which was framed to secure the humane handling of live stock in transit, it would seem," says the Secretary of Agriculture "that an additional provision should be incorporated therein requiring carriers to maintain a reasonable minimum speed on all stock trains."

Under the live-stock quarantine laws 148 cases were reported; 20 cases were disposed of, with fines amounting to $2,970. Fifty-two violations of the meat-inspection law were reported; 18 cases gave convictions, 8 were dismissed, and 26 are pending. Two cases were reported under the Lacey act for the protection of game; 1 was abandoned because of difficulty of proving interstate shipment; the other is pending. Four cases came over from the previous year; in 2 the grand jury failed to indict; in the other 2 fines were assessed.

The Aims of Astronomy of Precision*

A Resumé of Modern Methods

By S. S. Hough

The science of precise physical measurements is one which does not readily appeal to those not immediately concerned, either with the methods or results. An authoritative statement that the sun's distance from the earth is 92,880,000 miles may excite wonder, but scarcely more than will the statement that it is approximately 93,000,000, except in the minds of those who are in some measure acquainted with the laborious processes by which the two extra figures are derived. In fact, I have not infrequently heard the methods of observation used described by some such epithet as "hair-splitting." For this reason I think I cannot do better to-night than to describe to you, without entering into technical details of the methods employed, some of the aims and objects to which modern astronomy of precision is devoted, and which render essential the very highest refinements that human ingenuity can devise.

Perhaps the primary reason why astronomy appeals to the popular imagination in a higher degree than other sciences is that astronomy is *par excellence* the science of prediction. True, the days are now past when an astronomer was regarded, except by the most ignorant, as gifted with supernatural powers and capable of predicting events that can have no conceivable relationship with the objects of his researches, or when an unscrupulous astronomer could utilize his powers of prediction for imposing on the world at large in the face of the criticisms of fellow-workers in collateral branches of science. Nevertheless, it is only necessary to point to any of the leading almanacs to establish the undoubted claim of astronomy to a considerable predictive capacity in its own legitimate sphere. These almanacs, prepared in advance, give from day to day the positions of the sun and moon, the phenomena of eclipses, and various other data with an accuracy which can only be called in question by the most refined tests available to astronomers.

How, then, has astronomy acquired this faculty? The answer to this question is—at least primarily—by continuous and patient observation, using always the most refined methods of physical measurement available.

A well-devised scheme of observation is sooner or later bound to lead to the detection of laws governing physical phenomena if such laws exist. Thus it was the planetary observations of Tycho Brahe which led to the detection of the laws of planetary motion associated with the name of Kepler.

Once such laws have been established and the necessary initial data secured, the science of astronomical prediction would for the future devolve on the mathematician rather than the astronomer, were it not for two sources of uncertainty with which the astronomer must continue to concern himself. It is evident, on one hand, that we cannot infuse into our predicted phenomena greater precision than that derived from the initial data, themselves dependent on imperfect observations. However well the laws governing planetary motions may be understood, the predicted position of a planet to-day depends on its observed position at some earlier epoch or epochs; and the fallibility of the observations made at these earlier epochs will not only pervade all future predictions, but will inevitably increase in amount as the epoch of prediction recedes from the epoch of observation. For this reason, if the standard of accuracy of prediction is merely to be maintained—and the growing requirements of science will scarcely rest contented with this—continuous observation must be maintained and the data on which predictions are based revised from time to time.

I have dealt so far only with the effects of the unavoidable inaccuracies of observations, even when pushed to their utmost refinement, as influencing results of prediction. A second consideration of even greater importance is the validity of the laws associating the predicted with the observed phenomena. I may illustrate my point again by reference to the laws of Kepler. It is now well known that these laws are only rough approximations to the actual truth, and that though they might serve as a useful basis for prediction over a short interval, a few years at most would suffice, by showing a rapidly increasing departure between the observed and predicted positions of the planets, to indicate that these laws require amendment.

That the disclosure of direction which this amendment should take followed so soon on the original discovery of Kepler's laws was due to the genius of Newton, who showed that the theory of universal gravitation propounded by him not only adequately accounted for the laws enunciated by Kepler, and pointed to their imperfections, but served to co-ordinate as due to a single cause even more recondite phenomena, such as the leading inequalities in the motion of the moon, the precessional motion of the earth, and the phenomena of the tides. This theory further reduced to order those astronomical vagaries the comets, showing that, so long at least as they remained within the precincts of the solar system, their motions were governed by it, while observations of double stars have established beyond question that even remote parts of the universe are still subject to the same laws.

The dynamical laws propounded by Newton, which to-day virtually form the basis of all astronomical prediction, enable us to trace back as well as to trace forward the history of the solar system, and to confront modern observations with historical records. Needless to say, in but rare instances do these records possess the necessary elements of precision to strengthen the existing data required by the atronomer; but there are important exceptions. For instance, a very small uncertainty in the "elements," which in conjunction with Newton's laws govern the motion of the moon, will produce by lapse of time a large change in the comparatively small area of the earth's surface over which a total eclipse of the sun is visible as such. Thus a record that a particular eclipse was seen as total in a given locality becomes an observation of precision, provided only the chronological date at which the eclipse occurred can be traced with sufficient certainty to insure the identification of the eclipse concerned.

The confrontation of modern with historical observations of such a character has served to establish beyond question the high degree of accuracy with which the laws of Newton represent the motions within the solar system, and their trustworthiness as a basis of prediction for years, perhaps for centuries, to come. It is, however, on various grounds quite certain that these laws in themselves are not absolute, far-reaching though they are, and that they in turn, like those of Kepler, must be superseded by laws still more exact.

Until such laws are discovered there will always remain an element of uncertainty, apart from that due to the initial data affecting all predicted phenomena—an uncertainty which can only be removed when the phenomena cease to be prospective, and when they can be confronted with later as well as with earlier observations.

The fact, however, that the laws of gravitation yield such a close representation of the observed motions within the solar system throughout historic time renders the detection of a departure from these laws a question of extreme delicacy, but none the less essential, if prediction is to be secured for long periods in advance.

I have selected my illustrations largely from the solar system chiefly on the grounds that, thanks to the Newtonian laws, it is here that, in spite of the immense mathematical difficulties which have had to be faced, astronomical prediction has attained its greatest triumphs. I wish now to divert attention to the stars. In so far as these form the fiducial points to which the motions of the planets and other members of the solar system are referred, it is essential that the positions of a limited number, at least, should be determined with the highest possible accuracy. Any uncertainty in their positions will undoubtedly be reflected in the positions of the planets, and will constitute one of those sources of error so liable to increase with time, and render efforts at prediction, if not entirely nugatory, at least partially ineffective.

The universe of so-called "fixed stars" is not invariable in aspect, though its changes, for the most part, are of so minute a character that they can only be surely detected either by the most delicate measurements or by their cumulative effect over long intervals of time. It is chiefly through a study of these changes that our knowledge of the stellar universe has been acquired in the past, and it is largely to similar means that we look for an extension of this knowledge.

Among changes which lend themselves to observation for this purpose we may enumerate:

(1) Changes of the intensity of the light of the stars. The origin of these changes, except in a few instances, remains obscure. In certain cases, however, notably in the case of variable stars of the Algol type, a satisfactory explanation of the observed phenomena has been found in the motions of a system, governed by laws similar to those operating in our solar system, of which the visible star forms a constituent member.

(2) Changes of position due to orbital motion in binary or multiple stars. Where both components of a binary star are visible, these changes readily admit of direct measurement. In other cases the existence of a companion is inferred to account for regular periodic changes of position of the visible component, though this companion cannot be seen either on account of intrinsic want of light or on account of its close proximity to the primary, and the consequent incapacity of our telescope to render the two visually distinct.

These changes are of interest as affording evidence of the validity of the Newtonian laws in systems other than the solar system.

The changes to which I have so far referred are changes which affect isolated stars or groups of stars, but which do not occur, at least to a sensible extent, in the generality of stars.

I come now to the changes of position due to the earth's orbital motion which, on the other hand, may be expected to influence all stars in common. Even where, as in the cases I have already spoken of, their influence is obscured by orbital motion within the system, when once this orbital motion has been thoroughly examined, its laws deduced, and due allowance made for it by computation, we might expect to find the effects of the earth's motion still apparent.

The earth in its orbit round the sun approximately describes a circle of 186,000,000 miles in diameter, and its successive positions in space at intervals of six months are separated from one another by this extent. But experience has shown that recurring changes in the relative positions of the stars, as viewed at intervals of six months—that is to say, from two different points of the universe separated by this vast distance—can only be detected in the case of a limited number of stars, and then only by the application of the most delicate methods of measurement specially designed to bring these changes to light.

To the Cape Observatory and its former director, Henderson (1832-4), belongs the credit of first producing trustworthy evidence of the existence of any fixed star, for which these changes could be unmistakably detected, and which, therefore, was not too remote from the solar system to permit of its distance being at least roughly determined in comparison with the diameter of the earth's orbit. Henderson's discovery has since been fully confirmed by later observers, and other stars likely to yield tangible results have now been examined. As illustrative, however, of the evasiveness of the quantities sought, and the excessive labor by which only they can be derived, though the problem of stellar distance has always been in the forefront of astronomical interest, and has attracted the attention of several able observers, the number of stars for which well-determined parallaxes have been published up to the present day does not exceed some 400. This number is quite insignificant in comparison even with the number of stars visible to the naked eye without telescopic aid. Moreover, the stars investigated have been, in general, selected on the grounds of some *a priori* probability of their possessing a measurable parallax, either on account of apparent brightness or on account of their large apparent motion, and for this reason they can scarcely be regarded as typical of the generality of stars.

In order, then, to gage the depths of the visible universe it would appear imperative that our base line must in some manner be extended. The distance of 186,000,000 miles through which we are carried in the course of a single half year by the orbital motion of our planet round the sun is so small in comparison with interstellar distances as to give rise to changes in the apparent relative positions of stars which, except in the most pronounced instances, are so insignificant in amount as to defy detection even by the most refined processes of measurement we possess.

How, then, can such an extension of our base line be attained? I have already pointed out that the so-called "fixed stars" are not truly "fixed," but that on close observation it is found that each star has an apparent motion either peculiar to itself or shared by other neighboring stars which, with it, constitute an independent system. I refer primarily to the visible motion transverse to the line of sight.

If then our sun, as we may reasonably suppose, is itself a member of the stellar universe, it may be anticipated that it too will not be at rest, but will be moving forward in space, and the visible motions will be those due to the combined effects of the motion of the sun and stars.

That the apparent motions of the stars were not entirely fortuitous, but that they could, at least partially, be co-ordinated throughout the sky as the visible manifestations of a single phenomenon, viz., a translatory motion of the sun with its system of planets through interstellar space, was first pointed out by Sir William Herschel, who further indicated that the point of space to which this motion was directed was situated in the constellation "Hercules."

Before proceeding to the further consideration of this solar motion, I wish first to point out to you how its existence at once suggests a means of "extending our base-line" for the purpose of gaging these interstellar depths. I have refrained from any numerical estimates of the amount of this motion, as this involves philosophical questions into which I do not desire to enter to-night; but in order to fix our ideas it is necessary for me to give you some notion, at least, of the order of magnitude. It is now possible to state with some certainty that the speed of the sun's motion relatively to the stars as a whole amounts to about twenty kilometers per second, and that the space traversed in a single day therefore amounts to rather more than 1,000,000 miles, that in a year to about 400,000,000 miles. Thus the stars, as seen on two occasions a year apart, may be considered as viewed from two points in space separated by this length, and it only requires lapse of time in order to increase the length to an almost indefinite extent.

The great scheme for the photographic mapping of the heavens at present being carried out on an extensive scale by means of the co-operative efforts of the leading observatories of the world will shortly furnish a highly accurate delineation of the skies as seen at the commencement of the twentieth century. This alone has called for concentrated effort extending over some twelve years at least, while it would even now scarcely be safe to say that another ten years will see its completion. An immediate repetition is scarcely to be contemplated, though a subsequent repetition at some future epoch, which may be agreed on by astronomers, forms an essential part of the programme as originally introduced.

When this scheme is completed in its entirety very ample data will be available for the discussion of stellar distribution by the methods I have suggested to you.

In the meantime, however, in such tentative attempts as have been made to fathom the secrets of the universe by means of the study of stellar proper motion, it has been necessary to rely on early recorded exact observations. It will be clear from what I have already explained to you that it is the earliest trustworthy records in comparison with the most up-to-date available which

* From the presidential address delivered before the Royal Society of South Africa.

will yield the greatest length of base-line, and consequently the most trustworthy results. For this reason the majority of the discussions hitherto attempted have been based on the catalogue of Bradley, dependent on observations made by him at Greenwich between the years 1750-62. This catalogue contains the places of some 3,000 stars observed with a precision far surpassing any similar previous observations, and comparing favorably with the best modern catalogues. The stars selected by Bradley are fairly uniformly distributed over the portions of the sky accessible to him, viz., from the North Pole to 30 deg. south of the equator.

Unfortunately no early catalogue of stars of even approximately similar precision exists for the remaining region of the sky between 30 deg. S. dec. and the South Pole, and the absence of exact knowledge of these regions for the earlier epochs has always hampered these discussions.

The discussions I refer to have generally had as their immediate objective:

(1) The determination of the processional constant, *i. e.*, the annual amount by which the earth's axis of rotation changes its position in space, and

(2) The determination of the speed of the solar motion and the position of the solar apex, *i. e.*, the point in the heavens toward which the sun's motion is directed.

The discrepancies in these quantities found by different investigators, either starting with different data or utilizing different methods for the combination and discussion of the same material, had long been a puzzle to astronomers. The key to the situation was at length furnished by Prof. Kapteyn, of Groningen, who, in an epoch-making paper read before the British Association in Cape Town, first pointed out that the apparent motions of the stars indicated, not merely the existence of a single solar apex, but that there were two separate regions of the sky toward which a preference was shown by the directions of motion of the Bradley stars.

This was a phenomenon which could not be explained by a simple motion of translation of the sun, as evidently the sun's motion could not be directed to two different points simultaneously, and the only feasible explanation was that the stars consisted of two groups, and that the motion of the sun relatively to one of these groups differed from its motion relatively to the other, or that, though the stars appeared intermingled in space, they possessed an independent relative motion, which might be regarded as located in one group or in the other, but which was shared by all the stars peculiar to the group.

The theory of the existence of two streams or drifts of stars thus put forward by Kapteyn has since received full confirmation by other investigators, notably by Eddington, who based his examination on the early observations of Groombridge, and by Dyson, who limited his discussion to a selected list of stars possessing considerable proper motions.

Recent investigations at the Cape have led us to examine in somewhat more minute detail the proper motions of the Bradley stars, with the result that, though the phenomena first noticed by Kapteyn stand out as the most prominent feature, certain subsidiary features of no less importance have been brought to light.

I have concerned myself hitherto only with the visible motions of the stars transverse to the line of sight, as derived by the older methods of measurement. The introduction of the spectroscope into astronomical research has opened up vast new fields into which, so far as they relate to the chemical and physical constitution of the sun and stars, it is not my purpose to enter to-night. What I wish rather to emphasize is the value of this instrument as a supplement to the older methods in relation to the geometrical astronomy of position.

In accordance with the principle laid down by Döppler, the wave-length of light received from a source which is either receding from or approaching a receiver will appear to be modified by an amount dependent in a known manner on the velocity of approach or recession. If the receiver takes the form of a spectroscope which permits by any means, direct or indirect, of the measurement of the wave-lengths, and the normal wave-lengths of the lines under examination are independently determined by laboratory investigations, the difference between the observed and the normal wave-lengths will thus afford a means of measuring the velocity of approach or recession of the source of light.

Of the precautions necessary to ensure precision it is not my purpose to speak to-night. The large spectroscope of the Cape Observatory, which we owe to the munificence of the late Mr. Frank McClean, was from the outset constructed with due regard to these precautions, so far as they could be foreseen, for the purpose of determining with the greatest accuracy attainable the radial velocities of stars. The instrument has been already successfully used, and its capabilities have been established in an investigation of the aberration constant of light as depending on the apparent variations in the radial velocities of stars resulting from the earth's orbital motion.

From a relatively short series of observations discussed by my colleague Dr. Halm, this constant has been derived with a precision not inferior to that attained by the best series of older observations, and the capabilities of the method are yet far from exhausted.

At the present time the instrument is being devoted to a series of observations of all such stars as are accessible in the southern skies, the spectra of which present sufficiently pronounced features to admit of measurement, primarily with the view of ascertaining what evidence can be derived from a study of the radial velocities in regard to the systematic structure of the universe.

A year or two must elapse before the present observing programme is completed, but a preliminary discussion of the observations already secured in combination with the published results derived from similar observations in the Northern Hemisphere has revealed the existence of anomalies similar to those found from the study of the transverse motions—anomalies which can only be reconciled with the two-drift hypothesis put forward by Kapteyn by the further hypothesis that though both drifts pervade the whole sky, they are not similarly distributed throughout it.

At present, through scantiness of material, from a study of the radial velocities we have been able to do little more than discriminate between the two halves of the sky, which contain, respectively, the greatest and the least proportion of second drift stars. It is, however, a fact of some significance that the former corresponds very closely with that hemisphere which contains the Milky Way, suggesting the phenomenon that Kapteyn's second drift might be identified with the galaxy. It was with the view of examining this suggestion in the light of the evidence which could be secured from the transverse motions of the Bradley stars that the discussions I have sketched to you to-night were undertaken by Dr. Halm.

While they have established almost beyond question the rought features of distribution demanded to reconcile the radial-velocity determinations, they further point to an even more detailed correspondence between the distribution of galactic stars and the distribution of stars of the second drift, leaving but little doubt as to the idenity of this second drift with the galaxy. It is this second drift which exhibits evidence of structural unity. As regards the Milky Way, the mere appearance on any fine night affords evidence of a similar character, and it is on this account that we have been able to identify the Milky Way with the second drift rather than the first.

The significance and origin of this structure are as yet obscure, but the more its details are elucidated and the essential features established the nearer are we to an answer to the question, What is the Milky Way?

To revert to my original text, I have endeavored to point out to you the methods of research by which an answer is sought to this and similar questions, and to explain to you the reasons why the highest precision attainable is a *sine quâ non* in the conduct of such research. Thus it is that the study of the large-scale phenomena of the universe resolves itself frequently into a study of the minute detail of instrumental appliances, on which must be brought to bear all the knowledge that can be derived from other branches of scientific work. The geologist helps us in the selection of stable foundations on which the engineer may erect our large instruments. Chemistry and physics in our photography, our optical and electrical appliances, are of daily application, while one of the most valued accessories in almost all methods of precise measurement is the spider's web we devise from zoology.

Astronomy, in its turn, has done much in the past, and in the future will doubtless do more, to assist the development of collateral sciences. Thus the geologist cannot afford to ignore, even if he does not accept as conclusive, the evidence furnished by astronomy as to the nature of the earth's crust. Exact measurements of space and time as conducted in physical laboratories are for the most part conducted by methods first designed to suit the requirements of astronomical precision, while in the sun and stars chemical phenomena, which may be studied with the aid of the spectroscope, are taking place on a scale far surpassing anything that can be produced in the laboratory.

The value of free intercourse between workers in the various branches of science is certainly indisputable, and I wish to close my address by reference to the opportunities which our society can afford in this respect. Devotees even of applied, and still more of pure, science in a young country are necessarily few in number and scattered. A large proportion of these will in the early stages of their career have been in close association with one or the other great centres of scientific activity of the world, and to such a feeling of scientific isolation almost amounting to exile, and consequent lack of stimulus, is almost inevitable. Important as are our publications, it is even more through our monthly meetings and the promotion of personal intercourse that the society can help in its primary duty of the advancement of natural knowledge in South Africa.

Abandonment of the Weekly List of Patents.

Early in the present year, we transferred to the columns of the Scientific American Supplement *the list of patents which formerly appeared each week in the* Scientific American. *It was felt that the amount of space devoted to the list, an amount which increased year after year, could be better devoted to interesting reading matter. We asked our readers what they thought of the change. A number of protests were received, but a far greater number of approving comments.*

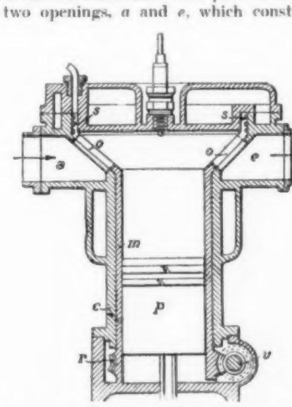
In view of these circumstances, the publishers have decided that if the readers of the Scientific American *did not want the weekly list of patents, the readers of the* Scientific American Supplement *were no more in favor of it.*

This, therefore, will be the last list of patents which will appear either in the Scientific American *or the* Scientific American Supplement.

The Renault Valveless Explosion Motor

The excellent performance of the Knight valveless motor, which has been adopted by the Panhard-Lievassor firm and several other automobile builders, has incited other inventors to endeavor to eliminate the admission and exhaust valves, which are costly and fragile, and which diminish the efficiency of the motor by introducing idle spaces.

The Renault firm, of Paris, has recently patented a valveless motor, the construction and operation of which are illustrated by the accompanying diagram of one cylinder. The piston *p* moves in a cylinder *m*, which rotates on its axis inside the fixed cylinder *c*, with an angular velocity equal to one-eighth that of the crank shaft. The rotation is produced by the endless screw *v* and the helically geared wheel *r*. Each cylinder is terminated above by a conical extension. This part of the outer cylinder has two openings, *a* and *e*, which constitute the admission and exhaust ports, and are placed at an angular distance from each other which is determined by the proper regulation of the motor. The conical head of the inner cylinder has four openings *o*, spaced at intervals of 90 degrees, which successively unmask the ports *a* and *e* as the cylinder rotates. These openings are bounded laterally by generating lines of the cone, and above and below by the horizontal planes which limit the conical portion of the cylinder.



THE RENAULT VALVELESS EXPLOSION MOTOR.

Leakage from the inner cylinder is prevented by the pieces *ss*. The igniter is placed at the center of the removable base of the cylinder.—*Le Génie Civil.*

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